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samples when required, or can send men with complete equipment
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Tests and Inspection of Steel for all kinds of Structures.

PROCEEDINGS

OF THE

SECOND CONVENTION

OF THE

NATIONAL ASSOCIATION

OF

CEMENT USERS,

Milwaukee, Wisconsin,
January 9th to 12th, 1906.

EDITED BY THE PRESIDENT.

PUBLISHED BY THE ASSOCIATION.

1906.

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HARVARD UNIVERSITY
DEPARTMENT OF ENGINEERING.

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LIST OF OFFICERS AND COMMITTEES
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CHARTER

OF

THE NATIONAL ASSOCIATION OF CEMENT USERS.

KNOW ALL MEN BY THESE PRESENTS, That we, the undersigned, all of whom are citizens of the United States, and a majority of whom are residents of the District of Columbia, have associated ourselves together for the purpose hereinafter set forth and desiring that we may be incorporated as an Association under sub-chapter three (3) of the Incorporation Laws of the District of Columbia, as provided in the Code of Law of the District of Columbia, enacted by Congress and approved by the President of the United States, do hereby certify:

1. Name. The name of the proposed corporation is "The National Association of Cement Users."

2. Term of Existence. The existence of the said corporation shall be perpetual.

3. Objects. The particular business and objects of the said corporation shall be to disseminate information and experience upon and to promote the best methods to be employed in the various uses of cement by means of convention, the reading and discussion of papers upon materials of a cement nature and their uses, by social and friendly intercourse at such conventions, the exhibition and study of materials, machinery and methods and to circulate among its members by means of publications the information thus obtained.

4. Incorporators. The number of its managers for the first year shall be fifteen.

In Witness Whereof, we have hereunto set our hands and seals this fourteenth day of December A. D., 1906.

RICHARD L. HUMPHREY, (SEAL)
JOHN STEPHEN SEWELL, (SEAL)
S. S. VOORHEES. (SEAL)

OFFICE OF RECORDER OF DEEDS,
DISTRICT OF COLUMBIA.

This is to certify that the foregoing is a true and verified copy of a Certificate of Incorporation, and of the whole of such Certificate as received for record in this office at 9:49 A. M., the 19th day of December, A. D. 1906.

In testimony whereof I have hereunto set my hand and affixed the seal of this office, this 20th day of December, A. D. 1906.

(Signed) R. W. DUTTON,
Deputy Recorder of Deeds,
District of Columbia.

(SEAL)

BY-LAWS OF THE NATIONAL ASSOCIATION OF CEMENT USERS.

ARTICLE I.

MEMBERS.

SECTION 1. Any company or persons engaged in the construction or maintenance of work in which cement is used, or qualified by business relations or practical experience to co-operate in the purposes of this Association, or engaged in the manufacture or sale of machinery or supplies for cement users, or a man who has attained eminence in the field of engineering, architecture or applied science, is eligible for membership.

SEC. 2. A company shall be treated as a single member and allowed but one vote.

SEC. 3. Application for membership shall be made to the Secretary on a form prescribed by the Executive Board. The Secretary shall submit a copy of the same to each member of the Executive Board and a two-thirds majority of those present at a Board meeting shall be necessary to an election.

SEC. 4. Resignations from membership must be transmitted in writing to the Secretary.

SEC. 5. Any member, after a fair hearing by first the Executive Board and then, with their approval, by this Association, be expelled from membership by a three-fourths ballot of the members present at any regular meeting of the Association, not less than twenty votes being cast. Such action shall be publicly announced.

ARTICLE II.

OFFICERS.

SECTION 1. The officers shall be a President, four general Vice-Presidents, a Vice-President for each section into which the Association may be divided, a Secretary and a Treasurer.

SEC. 2. These officers, except the Secretary and Treasurer, shall be elected by ballot at the Annual Meeting and shall hold office for one year. The Secretary and Treasurer shall be elected

annually by the Executive Board. Vacancies occurring during the year shall be filled by the Executive Board.

Sec 3. The Executive Board shall consist of these officers and the five latest living Past-Presidents.

Sec. 4. The Secretary shall be custodian of the Association property and shall forward all moneys received to the Treasurer, obtaining his receipt for the same. He shall give such bond as the Executive Board may require.

Sec 5. The Treasurer shall handle the funds of the Association subject to the approval of the Executive Board and shall give bond for the faithful performance of his duties in such sum as the Executive Board may designate. The Treasurer shall disburse funds only on warrant drawn by the Secretary and counter-signed by the President.

Sec. 6. It shall be the duty of the Executive Board to audit the accounts of the Secretary and Treasurer before each annual meeting.

Sec. 7. The Secretary and Treasurer shall receive a salary to be fixed by the Executive Board.

Sec. 8. The Association shall be divided into such sections as the Executive Board may determine by the enrollment of members of the Association in such sections as they may choose. The Chairmen of these sections shall be elected by the sections at the first section meeting provided on the programme of the Annual Convention, and shall be reported to the Association for election as Vice-Presidents of the Association at the general election. Standing committees of four additional members each shall be appointed by the President of the Association in consultation with the respective chairmen to aid them in their work.

Sec. 9. At the first regular section of the Annual Convention, the President shall appoint a committee on nomination of officers, and a committee on resolutions.

Sec. 10. The election of officers shall take place at the business session on the second day of the convention, and they shall assume office at the close of the convention and hold same until their successors are elected and qualified.

ARTICLE III.

MEETINGS.

SECTION 1. The Association shall meet annually, the time and place being determined by the Executive Board, and notice shall be mailed to all members at least twenty days previous to the date of meeting.

SEC. 2. Special meetings may be called whenever the Executive Board shall deem it necessary.

ARTICLE IV.

DUES.

SECTION 1. The fiscal year shall commence on the first of January and all dues shall be payable in advance.

SEC. 2. The annual dues of each member shall be five dollars ($5.00).

SEC. 3. Any member whose dues shall remain unpaid for one year shall forfeit the privilege of membership. If he neglects to pay his dues within thirty days thereafter and after notification from the Secretary, his name may be stricken from the roll of membership by the Executive Board.

SEC. 4. Upon the payment of a fee of Two ($2.00) dollars any person may attend the Annual Convention of the Association and enjoy all its privileges except the right to vote.

ARTICLE V.

AMENDMENTS.

SECTION 1. Proposed amendments to these By-Laws signed by at least three members, must be presented in writing to the Executive Board before November 1st, of each year. In the notices for this meeting the proposed amendment shall be printed. At the annual meeting the proposed amendment may be discussed and amended and may be passed to letter-ballot by a two-thirds vote of those present. If two-thirds of the votes obtained by letter-ballot are in favor of the proposed amendment, it shall be adopted.

SEC. 2. The Executive Board is authorized to number the articles and sections of the By-Laws to correspond with any changes that may be made.

PROCEEDINGS

SECOND CONVENTION.

This Society is not responsible, as a body, for the statements and opinions advanced in its publications.

ANNUAL PRESIDENTIAL ADDRESS

By Richard L. Humphrey.*

It is my pleasure to address you as President of the Association, which was launched so auspiciously at that memorable convention in Indianapolis barely one year ago. It would appear particularly fitting on the first anniversary of this Association that such an address should dwell on the development in the uses of cement.

It is an old but trite saying that "there is nothing new under the sun," and I am taking this opportunity not for the purpose of relating anything new, but merely to refresh your memory on the facts concerning the increasing uses of cement.

The very full programme which has been arranged gives promise of so much interesting information that I shall endeavor to make these remarks as brief as possible.

The use of cement is very old. That the ancient Phoenicians and Egyptians understood the use of mortar is attested by the ruins of their massive masonry structures,—the joints of which contain hardened mortar.

It is stated by some writers that there is evidence of the use of mortar as far back as 4350 B. C. That the Romans made use of mortar at an early date is shown by the writings of Vitruvius, but, we also learn from Pliny that these mortars were bad,—for he tells us that,—"the cause which makes so many houses fall in Rome resides in the bad quality of the cement."

*Consulting Engineer, Philadelphia, Pa.

From the downfall of the Roman Empire to the beginning of the 18th Century the manufacture of cement seems to have been discontinued. Such cement, mortars and concretes as survived the ravages of the elements had become so hard that Roman cement acquired a reputation for quality which led the earlier experimenters of the 18th Century to seek to recover this lost Roman art.

You are doubtless familiar with the impetus the use of cement received through the experiments of John Smeaton in 1756, by the patent issued to Parker for the manufacturing of Roman cement in 1796, and by the experiments of Vicat and Collet-Descotils.

Portland Cement proper, however, did not receive its birth until 1824, when John Aspdin received his patent for manufacturing Portland Cement, which he so named from its fancied resemblance to the building stone obtained from the Isle of Portland off the coast of England.

From this date to 1850 very little progress was made in England. In other parts of Europe the development from 1855 was steady and continuous.

Natural cement was first manufactured in this country by Canvas White in 1818 and reached its maximum development in 1899.

It was not until 1872 that American Portland Cement was manufactured by David O. Saylor, in Pennsylvania, in an experimental way. Three years later he was able to manufacture it successfully, and our first Portlant Cement was exhibited at the Centennial Exposition in 1876.

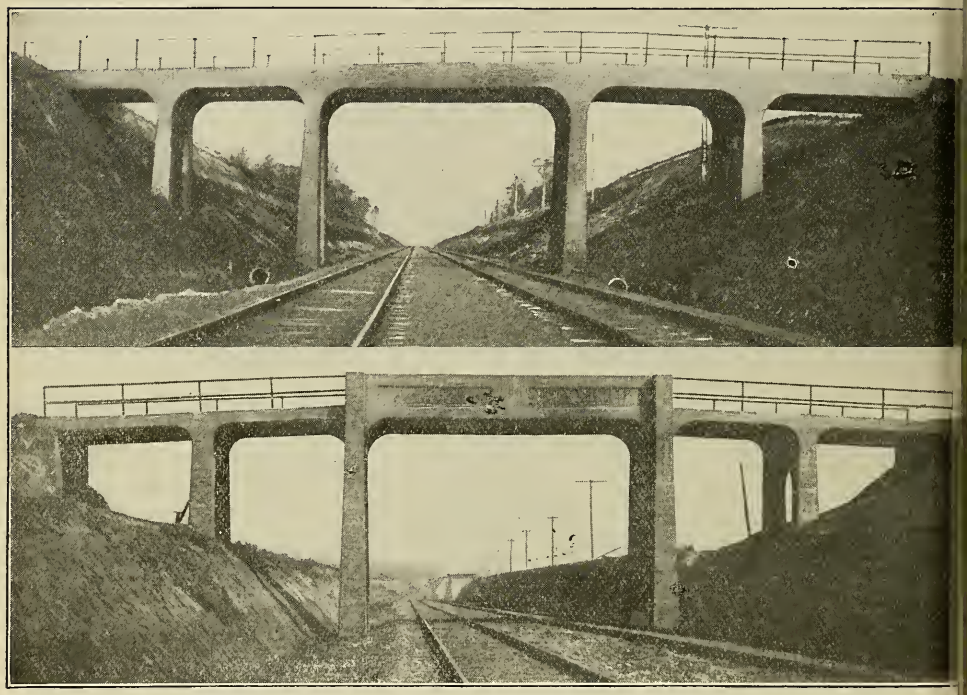
The slow development of this industry was due largely to strong prejudice against the American Portland Cement.

The successful introduction of the rotary kiln in 1889-1890 marks the beginning of the rapid and remarkable development both in the production and consumption of American Portland Cement. This is very clearly shown diagrammatically; the contrast between the capacity of the first cement plant in this country and the modern Portland Cement plants having capacities of from 2,000 to 10,000 barrels per diem, is just as great as the contrast between yearly production of 335,000 barrels in 1890 to the nearly 27,000,000 barrels produced in 1905. And this development is now not confined to one or

W. E. WARD HOUSE, CONCRETE SKELETON. BUILT 1875. NEW YORK.

two points, but is spreading over the entire country.

While it is true that the uses of cement in mortars for binding together masses of masonry or in concrete, is very old,—its use in the construction of arches, beams, columns and other structural parts is quite recent, and the remarkable development in the diverse uses to which it is put is all within



REINFORCED CONCRETE HIGHWAY BRIDGES OVER BIG FOUR RAILROAD.

the recollection of the present generation. These uses may be grouped as follows:

(1) In mortars, binding together large masses of stone or brick, etc., or for casting various forms,—e. g. artificial stone, hollow block, brick, etc.

(2) As concrete in mass or under conditions where it is only subjected to compressive stresses; and

(3) As reinforced concrete where it is subjected to both tensile and compressive stresses.

For the first part of group 1, it will be sufficient to observe that cement mortar is rapidly replacing lime and natural cement mortar.

It is worthy of record that on November 17th, 1850, Jos. Gibbs obtained a British patent for casting solid walls of concrete in wooden forms, while on March 6th, 1866, C. S. Hutchinson obtained a United States patent for hollow block

REINFORCED CONCRETE TRESTLE ON LINE BURLINGTON RAILROAD.

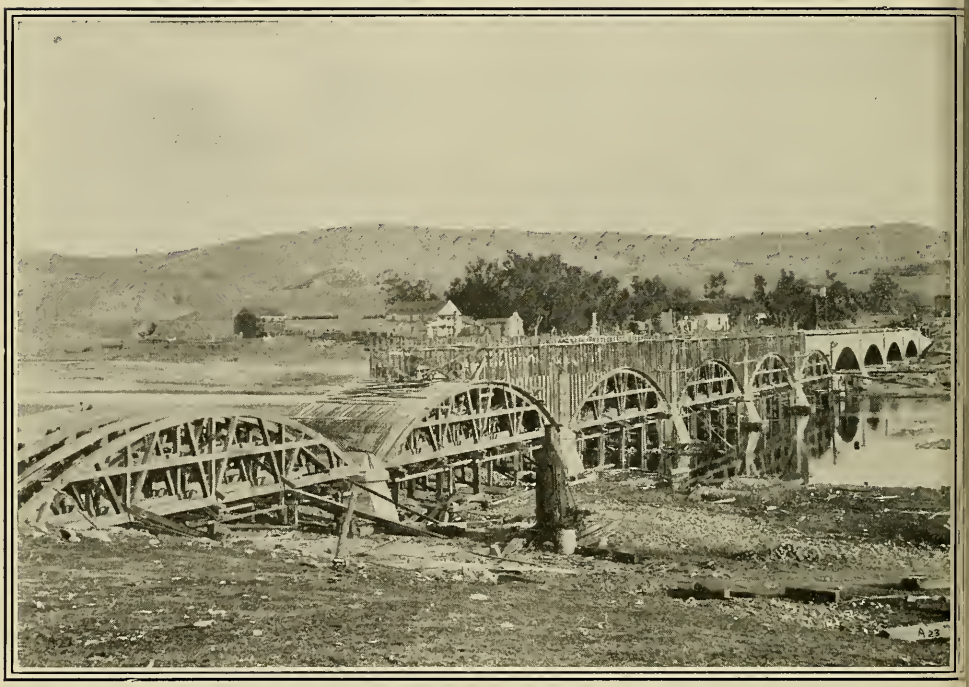
and brick walls making continuous vertical air spaces, and on April 14th, 1874, T. B. Rhodes also obtained a United States patent for hollow block and shingles. Patents were granted to C. W. Stevens for the manufacture of artificial stone in 1897, and to J. C. McClenahan in 1902.

The manufacture of artificial stone is now making progress and is successfully competing with cut stone work of ornamental character both in price and quality.

In the manufacture of hollow block there has been very

unusual development. This class of building material has come to stay and it will only be a question of time when matters will so adjust themselves that first-class material will be uniformly produced and it will form a very desirable substitute for brick and stone, and in cheapness will eventually compete with wood.

The use of cement has been quite general for many years

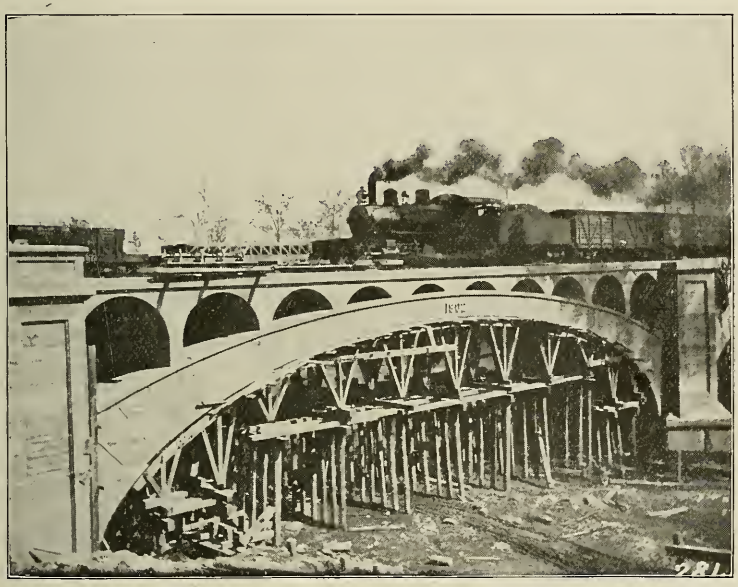


REINFORCED CONCRETE BRIDGE, POLLASKY, CAL.

for sidewalk work, and pavements of this character are by all odds the best attainable. As concrete, however, is deficient in edge strength, it has been found necessary to apply steel protection to the edges and there are patented excellent types of steel bound curbs on the market. The use of concrete for piers, abutments and arch bridges without steel reinforcement is too general to need comment. Additional information, however, is greatly needed as to the proper means for providing for the expansion and contraction of concrete in large masses. The

first concrete arch bridge was built in this country in 1870 in Prospect Park, Brooklyn, and to the Erie Railroad is given the credit of having lined the first tunnel with concrete, namely that at Bergen, N. J. in 1874.

A notable development in the use of concrete for bridges is illustrated in the construction of the bridge over Rock Creek in Washington. The voussoirs for the arches of this bridge are molded separately, are then air-hammered dressed



REINFORCED CONCRETE RAILROAD BRIDGE, ILLINOIS R. R. BRIDGE OVER BIG MUDDY RIVER.

and then hoisted into position; these blocks being handled similar to stone, holes being cut for the dogs. The spaces between these rings and the spandrel walls are cast in place with concrete. No sand is used in the concrete for the arch ring, crushed rock screenings being substituted and the bluish color of the rock produces a marked contrast to the color of the concrete used in the spandrel walls in which a yellowish sand is used.

Concrete sewers, retaining walls, and harbor bulkheads of plain concrete are also so extensively used that they are no longer a matter of special interest. Reinforced concrete,

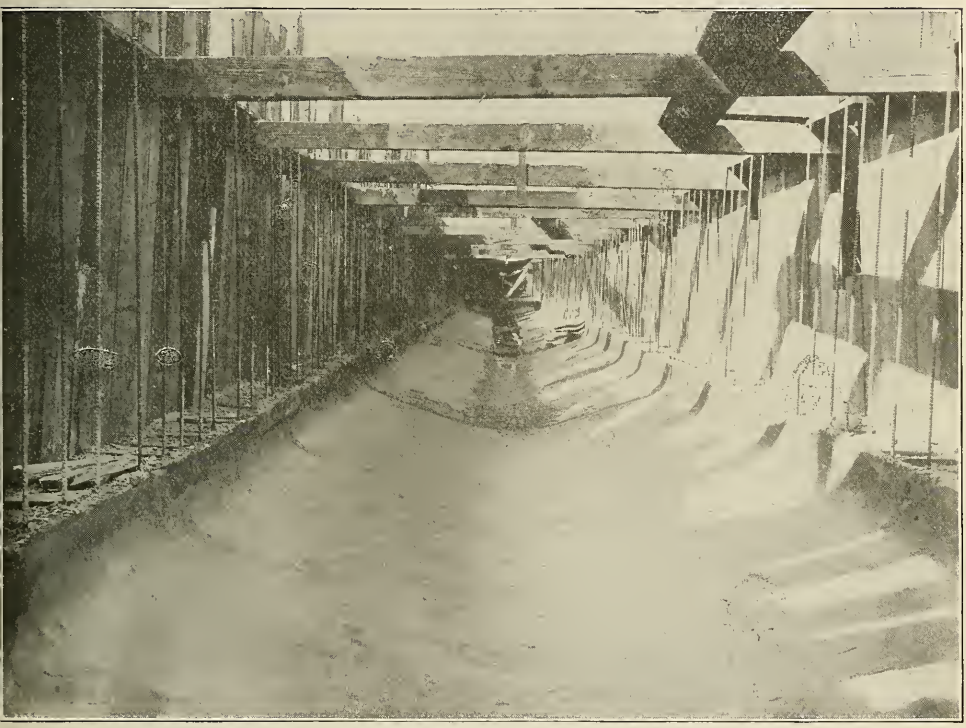
however, is of more recent development. The use of reinforced concrete was probably known prior to 1855, for at the Paris Exposition in that year a system of reinforced concrete was exhibited by Lambot. In 1861 Coignet proposed a method of reinforced concrete construction. The first application of metal reinforcement for concrete by Monier was in 1867 in the construction of some very large flower pots. In 1868

RAPID TRANSIT SUBWAY, BOSTON, MASS.

Monier obtained his first patent for reinforced concrete, but it was not generally used until after 1880, although in 1879 he again exhibited at the Antwerp Exposition a system of reinforced concrete construction.

The first reinforced concrete construction in this country is credited to W. E. Ward in 1875, who erected in New York City a house having the floors and columns of reinforced concrete. It should be noted that in 1876, Thaddeus Hyatt, an American engineer, published his experiments on reinforced

concrete in the laboratory of Kirkaldy, London, England. The experimental work of Hyatt extended from 1870 to 1880. The first Ransome patent was taken out in 1882, and it was applied in the construction of his first building in 1884. Between 1891 and 1894 Moeller in Germany, Muensch in Hungary and Melan in Austria were pioneers in the development of reinforced concrete construction in Europe. The use of reinforced

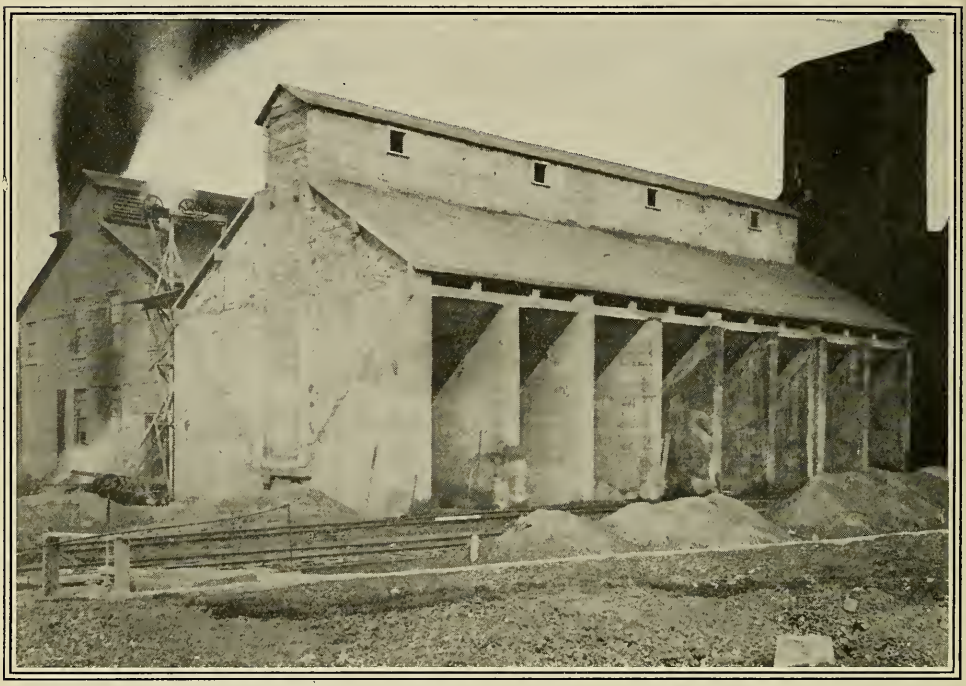


DRAINAGE CANAL, NEW ORLEANS, LA.

concrete on a large scale began in Germany under the system of Moeller in 1893 and Rabits in 1898. Hennebique had built reinforced concrete floors as early as 1879. It was not, however, until 1892 that he obtained a patent for his system of reinforced concrete construction.

The last ten years has seen a very remarkable development in reinforced concrete construction. At first reinforced concrete was used largely in the construction of bridges,

the first of which was built in this country over the Pennypacker Creek in Philadelphia in 1893, and for which I had the honor of inspecting the cement and other materials, as well as the construction of the bridge. From this beginning the use of reinforced concrete has developed rapidly and we find it is used in almost every conceivable form of construction. Large sewers, water pipes, reservoirs, coal bunkers,

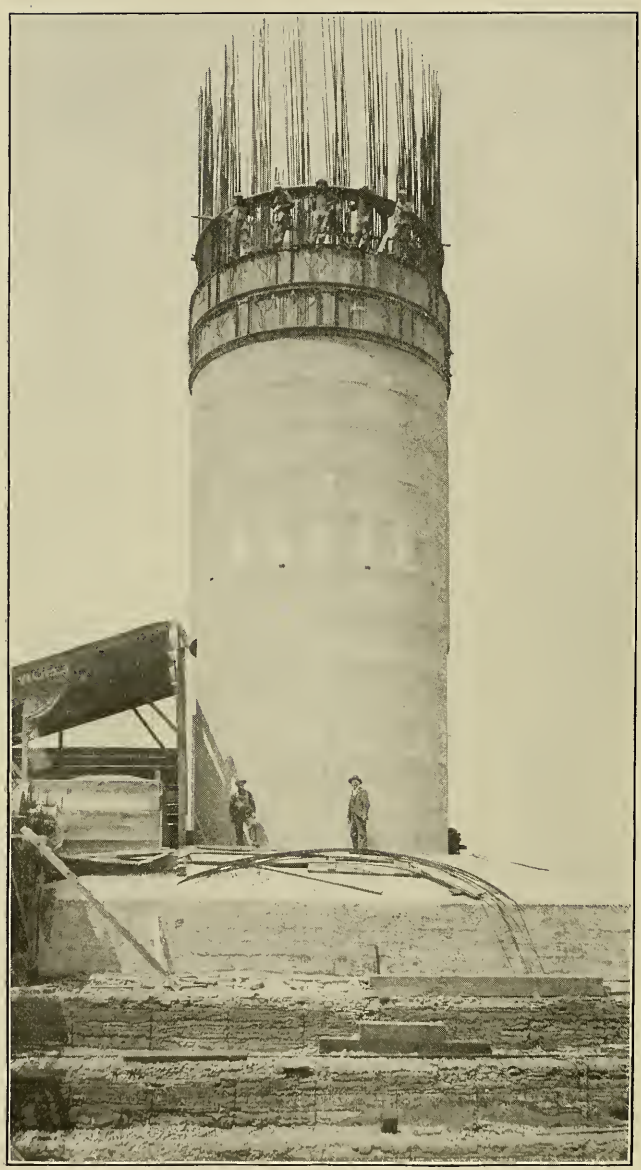


REINFORCED CONCRETE COAL POCKETS, BATH, PA.

pneumatic dams, chimneys, grain storage bins, bridges, buildings, being some of the many applications.

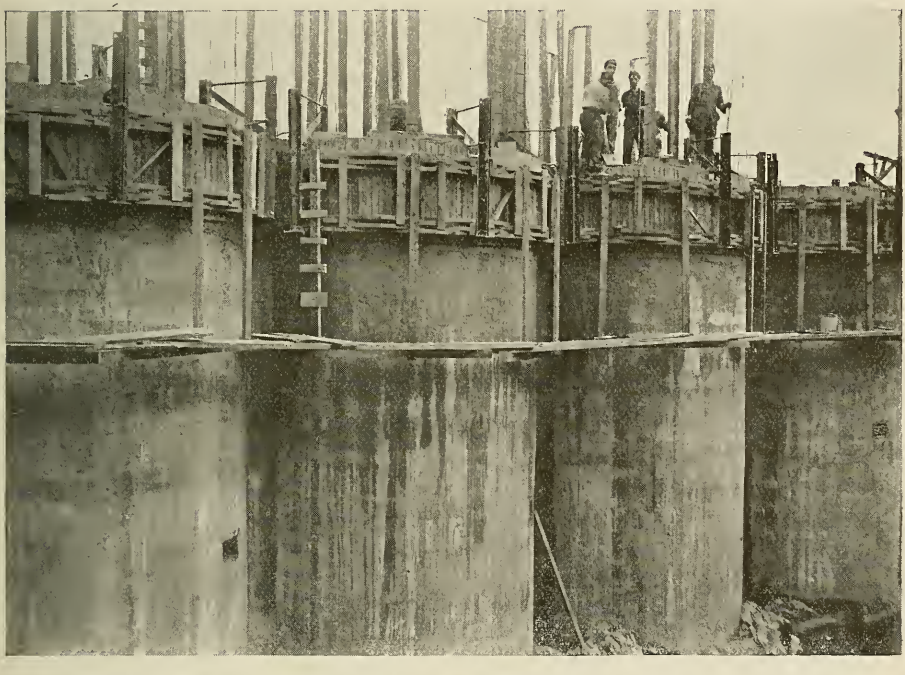
Experiments have been made in the Reclamation Service for its application in large reinforced concrete pipes of five feet in diameter and capable of standing upwards of 70 pounds in pressure, while one of the most novel and recent applications of reinforced concrete is for reinforced crib work, under the Frazer system, which it is stated costs a little more than timber cribbing, and which has been used extensively in Canada. Chimneys 350 feet in height have also been successfully

REINFORCED CONCRETE CHIMNEY, 350 FEET HIGH, 18 FEET DIAMETER, FOR COPPER SMELTER IN MONTANA.



REINFORCED CONCRETE CHIMNEY IN PROCESS.

constructed of reinforced concrete. The Harvard stadium, the baseball stand in Cincinnati, and the stadium of the Washington University at St. Louis are all novel examples of the use of reinforced concrete, while concrete ties reinforced in various ways have been in use for some time though they have not been satisfactory as regards cost. The cost of maintenance, however, has been found to be reduced to a nominal



REINFORCED CONCRETE GRAIN STORAGE BINS, PHILADELPHIA, PA.

sum and all the alignment very easily maintained, which greatly offsets the first cost. The rigidity of the roadbed, however, has been a prime objection, and an effort is now being made to introduce an elastic cushion in the tie in order to overcome this objection.

It is in the erection of office buildings of considerable height that the development has been most remarkable. Buildings 18 stories in height are being erected in which the skeleton is of reinforced concrete. Considering that the use of steel for reinforcing concrete beams was not suggested until

1882, a development of this character is certainly remarkable and we have reason to pause and consider whether such extreme development is wise.

While visiting a large city recently, I had occasion to inspect a building several stories in height in which cinder concrete is being used in the structural parts. The contractor, in reply to my surprised query, stated that the building was still standing. This was indeed true, but what was the mar-

DRIVING A CONCRETE PILE.

gin of safety in this structure? As this concrete had a compressive strength about half of what could be expected from a fairly good concrete, the factor of safety had therefore been cut in half. In further explanation he stated that in order to compete with other contractors, he was obliged to use the same materials which they did. The use of inferior materials should not be permitted in reinforced concrete construction, and the present situation in the development of concrete and reinforced concrete is one that should be faced squarely. That it is possible to erect a sixteen story building of reinforced concrete has been demonstrated,—but we should have a better

INGALLS BUILDING, 16 STORIES, STRUCTURAL SKELETON, REINFORCED CONCRETE, OF CINCINNATI, OHIO.

knowledge of the properties of this material before such a practice becomes general. Ten years or less experience with a material in which chemical changes are constantly going on and which may be affected by the changes produced by expansion and contraction is hardly sufficient to enable us to obtain a thorough knowledge of its properties.

The American Society of Civil Engineers recognized the

REINFORCED CONCRETE HOTEL, CALIFORNIA.

vital importance of this subject and recently appointed a committee on concrete and reinforced concrete, with instructions to affiliate itself in its work with similar committees of the American Society for Testing Materials, The American Railway Engineering and Maintenance of Way Association and the Association of American Portland Cement Manufacturers. After over a year's work they have found that:—

(1) Thoroughly reliable data upon which they can formulate a report as to the rules and formulae to be used in the design of reinforced concrete structures do not exist.

(2) That the results of the tests made in laboratories of the various technological institutions are not sufficiently comparable nor correlated for the purpose of obtaining these data; and

(3) That in order to secure the requisite data it will be necessary to conduct a complete series of tests in one labor-

ORNAMENTAL WORK MADE OF PORTLAND CEMENT (CAST STONE.)

atory where the conditions are as uniform as it is practical to obtain them and where the personal equation is reduced to the minimum.

This requires considerable money. Fortunately the small appropriation made to the United States Geological Survey for the investigation of structural materials has been applied to this work and the investigations have been inaugurated under the direction of an Advisory Board on Fuels and Struc-

tural Materials by the United States Geological Survey in co-operation with the Joint Committee on Concrete and Reinforced Concrete of the American Society of Civil Engineers and affiliated societies. In the absence of reliable data and under the conditions in the present state of the art, the courage to erect eighteen story buildings must command our admiration. I do not wish to be deemed pessimistic or overly conservative, for my belief in the future of concrete and reinforced concrete is absolutely unshaken, and I feel that the use of cement will so expand during the next few years that it will go beyond the limits of its most ardent advocate, but I do wish to point out the dangers which will result from its indiscriminate and fool-hardy use and to protest against the people who rush in and guarantee ridiculous things in concrete construction.

Concrete fills an important and growing field, but it has its weaknesses and its limitations and they should be pointed out and recognized squarely by its advocates. It is evident to any one who delves into the subject that reliable data for use in design of concrete structures are very much needed, and the work the Joint Committee on Concrete and Reinforced Concrete is doing in co-operation with the United States Geological Survey should receive the encouragement and support of each one present, and I would ask you to use every effort in urging upon your Congressman the vital importance of securing an appropriation for the continuance and completion of this very important work, for the attainment of reliable and uniform data for use in the design of structures in concrete and reinforced concrete will insure a more rapid, safe and successful development in the use of cement.

CONCRETE AGGREGATES.

By Sanford E. Thompson.*

The term "aggregate" includes not only the stone but also the sand which is mixed with cement to form either concrete or mortar; in other words, it is the entire inert mineral material. This definition, now generally accepted, has replaced the one restricting the term to the coarse aggregate alone.

It is the object of this paper to enumerate briefly the general principles which should be followed in the selection of sand and stone for mortar and concrete, and to briefly describe the method of testing aggregates and determining proportions which the author has found to give good results in practice.

At the outset it may be said that a concrete of fair quality, if rich enough in cement, can be made with nearly any kind of mineral aggregate, but there is, nevertheless, a wide variation in the results produced. For the fine aggregate, sand, broken stone screenings, pulverized slag, or the fine material from cinders may be used, separately, or in combination with each other. For the coarse aggregate, broken stone, gravel, screened gravel, slag, crushed lava, shells, broken brick, or mixture of any of these may be employed. However, the very fact of the adaptability of concrete to so wide a range of materials,—every one of which really consists of a large class varying in size, shape and composition,—tends to blind one to the economies which often may be effected and the improvement in quality which almost always will result by a careful selection and proportioning of the aggregates.

In many cases, especially where the cost of Portland cement is low, it may be cheaper to use whatever materials

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are nearest at hand, and insure the quality of the concrete or mortar by making it excessively rich in cement. If the structure is small and of little importance, this course is properly followed, but, on the other hand, if a large amount of concrete is to be laid, and especially if the process is to be carried on in a factory—as in concrete block manufacture—it pays from the standpoints of both quality and economy to use great care in the selection of the aggregates as well as of the cement and to provide means for maintaining uniformity.

To illustrate the variation which different aggregates may produce even when they are mixed with cement in the same proportions, the author has selected a few comparative tests of mortar and concrete.

EFFECT OF DIFFERENT AGGREGATES UPON THE STRENGTH OF MORTAR AND CONCRETE.

Tests by Mr. René Feret,* of France, with mortar made from different natural sands show a surprising variation in strength, which is evidently due simply to the fineness of the sand of which the different specimens are composed. Selecting from his results proportions 1:2:5 by weight—that is, one part cement to 2½ parts sand—and converting his results at the age of five months from French units to pounds per square inch, the average tensile strength of Portland cement mortar made with coarse sand is 421 pounds per square inch, with medium sand 368 pounds per square inch, and with fine sand 302 pounds per square inch. In the crushing strength, usually the most important consideration, the difference is even more marked. In round numbers, at the age of five months the mortar of coarse sand gave 5,200 pounds per square inch, the medium sand 3,400 pounds per square inch, and the fine sand 1,900 pounds per square inch. Note that the different sands were not artificially prepared, but were taken from the natural bank, and correspond to those which every day are being used for concrete and mortar.

The effect of different mixtures of the same kind of material is shown by tests with which the author has been connected during the past year, but the results of which have

*Taylor and Thompson's "Concrete, Plain and Reinforced," 1905, p. 136.

not yet been published. By varying the sizes of the particles of the aggregates, but using in all cases stone from the same ledge and the same proportion of cement to total aggregate by weight, namely 1:9 (or approximately 1:3:6), he found it possible to make specimens the resulting strengths of some of which were 2½ times the strengths of others.

The effect of the hardness or strength of the stone used for the coarse aggregate is shown in tests of George W. Rafter,* which, for proportions about 1:2:6:5, gave 50 per cent. greater compressive strength of concrete where the coarse aggregate was a hard sandstone than, with similar proportions, where a shale was substituted. In some of his tests the harder stone gave a concrete even double the strength of the concrete with the softer stone.

GENERAL PRINCIPLES FOR SELECTING STONE.

The quality of concrete is affected by the hardness of the stone, the shape of the particles, the maximum size of the particules; and the relative sizes of the particles.

If broken stone is used, and there is an opportunity for choice, the best is that which is hard; with cubical fracture; with particles whose maximum size is as large as can be handled in the work; with the particles smaller than, say, ¼ inch screened out (to be used as sand); and with the sizes of the remaining coarse stone varying from small to large, the coarsest predominating.

If gravel is used, it must be clean; the maximum size of particles should be as large as can be handled in the work; grains below, say ¼-inch should be screened out (to be used as sand); and the size of the stones should vary with the coarsest predominating.

I have said that the size of the coarsest particles of stone should be as large as can be handled in the work. This is because the strength of the concrete is thereby increased, and a leaner mixture can be used than with small stone. In mass concrete, the stones, if too large, are liable to separate from the mortar, unless placed by hand or derrick as in rubble concrete, and a practical maximum size is 2½ or 3 inches. In thin walls, floors and other reinforced construction, a

*Second Report on Genesee River Storage Project, 1894.

1-inch maximum size is generally as large as can be easily worked between the steel. In some cases where the walls are very thin, say, 3 or 4 inches, a ¾-inch maximum size is more convenient to handle.

It is a little more trouble, but almost always best, to screen out the sand from gravel, or the fine material from crusher stone, and then remix it in the proportions required by the specifications, for otherwise, the proportions will vary at different points, and one must use and pay for an excess of cement to balance the lack of uniformity.

If gravel is used, it is absolutely essential that it shall be clean, because if clay or loam adheres to the particles, the adhesion of the cement will be destroyed or weakened. Tests of the Boston Transit Commission* give an average unit transverse strength of 606 pounds per square inch for concrete made with clean gravel as against 446 pounds per square inch when made with dirty gravel.

COMPARATIVE VALUES OF DIFFERENT STONE.

Different stones of the same class vary so widely in texture and strength that it is impossible to give their exact comparative values for concrete. A comparison by the author of a large number of tests of concrete made with different kinds of stone, indicates that the value of a broken stone for concrete is largely governed by the actual strength of the stone itself, the hardest stone producing the strongest concrete. This forms a valuable guide for comparing different stones. Comparative tests indicate that different stones in order of their value for concrete are approximately as follows: (1) Trap; (2) Granite; (3) Gravel; (4) Marble; (5) Limestone; (6) Slag; (7) Sandstone; (8) Slate; (9) Shale; (10) Cinders. Although, as stated above, the wide difference in the quality of the stone of any class makes accurate comparisons impossible—and this difficulty is increased by the fact that the proportions and age of the specimens affect their relative value—an approximate estimate drawn from actual tests, gives the value for concrete of good quality sandstone as not more than three-fourths the value of trap, and the value of slate as less than half that of trap. Good cinders nearly

*Seventh Report of Boston Transit Commission, 1901, p. 39.

equal slate and shale in the strength of concrete made with them.

The hardness of the stone grows in importance with the age of the concrete. Thus gravel concrete, because of the rounded surfaces, at the age of one month may be weaker than a concrete made with comparatively soft broken stone, but at the age of one year it may surpass in strength the broken stone concrete because, as the cement becomes hard, there is greater tendency for the stones themselves to shear through, and the hardness of the gravel stones thus comes into play. Gravel makes a dense mixture, and if much cheaper than broken stone, can usually be substituted for it.

A flat grained material packs less closely and generally is inferior to stone of cubical fracture.

GENERAL PRINCIPLES FOR SELECTING SAND.

The only characteristics of sand which need be considered are the coarseness and relative coarseness of its grains and its cleanness. These qualities affect the density of the mortar produced; and therefore the test of the volume of mortar, or "yield," determines which of two or more sands is best graded. The "yield" or "volumetric" test I consider of greater value for quick results than all others put together. The methods of employing it are described farther along in the paper.

The best sand is that which produces the smallest volume of plastic mortar when mixed with cement in the required proportions by weight.

A high weight of sand and a corresponding low per cent. of voids are indications of coarseness and good grading of particles; but because of the impossibility of establishing uniformity in weighing or measuring, they are merely general guides which cannot under any conditions be taken as positive indications of true relative values. The various characteristics of sands are separately considered in the following paragraphs.

WEIGHT OF SAND.—A heavy sand is generally denser, and therefore better than a light sand. However, this is not a positive sign of worth, because the difference in moisture may affect the weight by 20 per cent., and when weighed

dry the results are not comparable for mortars, since a fine sand takes more water than coarse.

As an illustration of the variation in weight of natural sands having different moisture, the author found that the weight per cubic foot of Cowe Bay sand, which, dry, averaged 103 pounds, when placed out of doors and weighed after a rain in exactly the same way (although it was allowed to drain for two days) averaged 83 pounds.

VOIDS IN SAND.—The voids, like the weight, are so variable in the same sand, because of different percentages of moisture and different methods of handling, that their determination is of but slight value. In the Cowe Bay sand just mentioned, the voids were 38 per cent. in the sand, dry, and 52 per cent. in the same sand, moist.

Because of such discrepancies the author prefers to mix the sand with the cement and water, and determine the voids in the fresh mortar, as described later. This gives a true comparison of different sands, since with the same percentage of cement, the mortar having the lowest air plus water voids is the strongest.

COARSENESS OF SAND.—A coarse sand produces the densest, and, therefore, the strongest mortar or concrete. A sufficient quantity of fine grains is valuable to grade down and reduce the size of the voids, but in ordinary natural material, either sand or screenings, there will be found sufficient fine material for ordinary proportions, such as 1:1, 1:2, or 1:2½. For leaner proportions, such as 1:4 or 1:5, and sometimes 1:3, an addition of fine particles will be found advantageous to assist the cement in filling the voids. A dirty sand, that is, one containing fine clay or other mineral matter, up to, say, 10 per cent., is actually found by tests to be better than a clean sand for lean mortars.

For water-tight work it is probable that a larger proportion of very fine grains may be employed than for the best results in strength. This is a question, however, which has not yet been thoroughly investigated.

Feret's rule for sand to produce the densest mortar, is to proportion the coarse grains as double the fine, including the cement, with no grains of intermediate size. There is difficulty in an exact practical application of this rule, but it

indicates the trend to be followed in seeking maximum density and strength.

CLEANNESS OF SAND.—An excess of fine material or dirt, as has just been noted, weakens a mortar which is rich in cement. It may also seriously retard its setting. My attention was recently called to a concrete lining, one portion of which failed to set hard for several weeks, although the same cement was used as on adjacent portions of the work. The difficulty proved to be due entirely to the fact that the contractor substituted, in this place, a very fine sand, the regular material happening to run low.

SHARPNESS OF SAND.—Notice that the quality of sharpness has not been mentioned among the essential characteristics of sand. This omission was intentional. The majority of specifications still call for "sharp" sand, and yet I have never known—and I venture to predict that none of those present have ever known—a sand to be rejected simply because of its lack of sharpness. As a matter of fact, if two sands have the same sized grains, and contain an equal amount of dust, the one with rounded grains is apt to give a denser and stronger mortar than the sharp grained sand. A sand with a sharp "feel" is preferable to another, not to any extent because of its sharpness, but because the grittiness indicates a silicious sand which is apt to have no excess of fine material.

SAND VS. BROKEN STONE SCREENINGS.—Many comparative tests of sand and screenings have been made with contrary results. While frequently crusher screenings produce stronger mortar than ordinary sand, the author in an extensive series of tests, has found the reverse to be true. This disagreement is probably due to the grading of the particles, although in certain cases the screenings may add to the strength because of hydraulicity of the dust when mixed with cement.

TESTING SAND.

In the previous paragraphs are shown the defects in the more common methods of examining sand.

I now venture to propose a test for sand which I am using constantly in my experiments for clients. Tests which I made in 1903 proved to me the value of the principles of

density of mortars laid down by Feret, and in the winter of that year similar plans for testing aggregates were introduced by Mr. William B. Fuller and myself at Jerome Park Reservoir, New York City. The object of the test is to determine which of two or more sands will produce the denser, and, therefore, the stronger mortar, in any given proportions. From the result of tests, the relative strengths of two different mortars can be approximately estimated without resorting to actual tensile or compressive tests.

In opening this paper I have given the different results in strength which Mr. Feret found with coarse, medium and fine sands respectively, these relative strengths in compression being respectively, 5,200, 3,400 and 1,900 pounds, with proportions 1:2½ by weight in each case. An examination of the tests shows that the strongest mortar was also densest, that is, the smallest volume, or yield, of mortar was produced with a given weight of aggregate.

The mortar with medium sand occupied a volume 7½ per cent. in excess of the volume of the mortar with coarse sand; and the mortar of fine sand, a volume 17 per cent. in excess of the mortar with coarse sand.

Following these principles, two sands may be compared and the better one selected by determining which produces the smallest volume of mortar with the given proportions by weight.

Using the method described below, the author has been able to increase the strength of a mortar about 40 per cent. by merely changing the sizes of grains of the aggregate.

The method of making the test is as follows: If the proportions of the cement to sand are by volume, they must be reduced to weight proportions; for example, if a sand weighs 83 pounds per cubic foot moist, and the moisture found by drying a small sample of it at 212° Fahr. is 4 per cent., which corresponds to about 3 pounds in the cubic foot, the weight of dry sand in the cubic foot, will be 83—3=80. If the proportions by volume are 1:3, that is, one cubic foot dry cement to three cubic feet of moist sand, and if we assume the weight of the cement as 100 pounds per cubic foot, the proportions by weight will be 100 pounds cement to 3×80=240 pounds of sand, which corresponds to proportions 1:2 by weight.

A convenient measure for the mortar is a glass graduate, about 1½ inches in diameter, graduated to 250 cubic centimeters. A convenient weight of cement plus sand, for a test, is 350 grams. For weighing, I employ Harvard Trip scales, which weigh with fair accuracy to one-tenth of a gram. The sand is dried and mixed with cement, in the calculated proportions, in a shallow pan about 10 inches in diameter and one inch deep. The mixing is conveniently done with a 4-inch pointing trowel. The dry mixed material is formed into a circle, as in mixing cement for briquets, and sufficient water added to make a mortar of plastic consistency, similar to that used in laying brick masonry. After mixing five minutes, the mortar is introduced about 20 c. c. at a time into the graduate, and, to expell any air bubbles, is lightly tamped with a round stick with a flat end. The mortar is allowed to settle in the graduate for one or two hours until the level becomes constant, when the surplus water is poured off, and the volume of the mortar in cubic centimeters is read. For greater exactness a correction may be introduced for mortar remaining on pan and trowel. The other sands, which are to be compared with this one, are then mixed with cement in the same proportions by dry weight, and sufficient water added to give the same consistency. The percentage of water required will vary with the different aggregates, the finer sand requiring the more water. After testing all the mortars, the sand which produces the strongest mortar is immediately located as that in the mortar of lowest volume. By systematic trials, the best mixture of two or more sands may also be found.

In some cases a correction must be introduced for the specific gravity of the sand; for example, ordinary bank sand has an average specific gravity of 2.65, but if this is to be compared with broken stone screenings having a specific gravity of, say, 2.80, the proportions of the two must be made slightly different. For these particular specific gravities, proportions 1:3, by weight, with sand, correspond in absolute volume to proportions 1:3.2, by weight, of the screenings.

In making these tests, it is also important to notice the character of the mortar as it is being mixed. It should work

smooth under the trowel and be practically free from air bubbles.

CALCULATING RELATIVE STRENGTHS OF MORTARS.

From the results of the tests described, it is possible to very closely estimate the relative strength of different mortars made with the same cement. A formula is given by Mr. Feret* for calculating the strength from the absolute volumes of the ingredients of the mortar, but wishing to avoid the calculation of the absolute volumes and obtain the result directly from the weights of the materials and the volume of the mortar made from them, I have found it possible to evolve from Feret's formula one which makes use only of the data from the tests in the graduates above described.

The formula is as follows:—

Let

P=compressive strength of mortar in pounds per square inch;

K=a constant;

Q=measured volume or quantity of mortar in cubic centimeters;

C=weight of cement used in grams;

S=weight of sand used in grams;

gc=specific gravity of cement;

gs=specific gravity of sand;

Then

$$P=K\left(\frac{g\,s}{g\,c}\right)^2\left(\frac{C}{(gsQ-S)}\right)^2$$

This formula may be readily altered to apply to the English system of weights and measures.

The value of K varies with different cements and different ages of the same mortar, hence, it is simplest to disregard the actual strength, and consider the relative strengths of any two or more mortars as in direct proportion to the values of the square of the quantities in brackets.

If the aggregates to be compared have similar specific gravity as is the case with different natural sands, the relative strengths of the mortars will be in proportion to the values of $\left(\frac{C}{gsQ-S}\right)^2$

*Taylor and Thompson's "Concrete, Plain and Reinforced," 1905, p. 139.

To illustrate the practical value of the formula, aside from theory, it may be of interest to refer to a recent series of comparative tests made in my own laboratory. A mixture of sand and cement in proportions 70 grams cement to 276 grams sand produced in the graduate a volume of mortar of 178 c. c. After making a number of trial tests, using in every case the same proportions by weight, a new mixture of sizes of the same aggregate was obtained, whose volumes when mixed with the cement and water was 165 c. c. The specific gravity of the sand, which in this instance was crushed rock, in both cases was 2.88. Substituting these values in the formula, we find the ratio of the two tests to be 1 to 1.40, that is, the mortar having the smallest volume ought to be 1.40 times (or 40 per cent.) stronger than the other. Actual tests of the two mortars, afterwards made in similar proportions into long prisms, gave at the end of 14 days an average of 832 pounds per square inch for one and 1,153 pounds per square inch for the other, thus showing an actual excess of strength of 39 per cent., which is substantially identical with the estimated increase.

TESTING CONCRETE AGGREGATES.

For concrete in any given proportions, the best sizes of stone and of sand may be determined by similar methods to those described for testing sand mortars, although larger quantities of materials must be used and the measure must be strong to withstand the light ramming which is necessary. A short length of cast iron pipe, closed at one end, may be used for this.

The aggregates, which mixed with cement in the required proportions produce the smallest volume of concrete, are usually the best, although, as already indicated, the shape of the particles and their hardness must also be taken into consideration.

PROPORTIONING CONCRETE.

Lack of time forbids the description of the application of these methods to determining the relative proportions of two or more aggregates in a concrete. Here again we have the general principle that the weight of material and the percentage of cement remaining the same, the mixture producing the smallest volume of concrete is the best.

DISCUSSION.

PRESIDENT HUMPHREY:—The paper is now open for discussion. Mr. Cummings, would you not like to say something on this subject?

MR. CUMMINGS:—I have studied the subject of aggregates for concrete during the past two years very much on the same lines as Mr. Thompson. To illustrate in a practical way the importance of aggregates, I may say that generally I took a 1:3:7 mixture of sand and ordinary gravel with cement and made a water-tight concrete out of it. That was only possible, as you all know, by perfect balancing of the aggregates so that a dense concrete could be obtained. Ordinarily speaking, 1, 2 and 4 concrete is considered almost water-tight when it is carefully made. The point that I want to bring out is that the density of the concrete is the object desired. The denser the concrete the more perfect the material. There is one point I am sorry that Mr. Thompson is not here to answer, and that is this: What effect has the dust of crusher run stone upon the mixture? There is another point that ought to be mentioned, and that is the influence of air. In order to obtain a perfectly dense concrete it is absolutely necessary that the air shall be worked out of it, and it is a very difficult matter to get air out of concrete in ordinary practical work, although easy in laboratory tests. One suggestion might possibly be to use very wet concrete.

MR. SEAFERT:—I want to take exception to Mr. Thompson's remarks about clean sand. Some of our colleges have found that an addition of 6 per cent. of clay improves it. The University of Wisconsin, at Madison, Wis., has included as much as 10 per cent. of clay in their clean sand, and they found that the test pieces were much stronger and denser. What is clay? It is simply silica and alumina. Your sand is largely or entirely silica. The Chicago, Milwaukee & St. Paul Railway Company has made many tests of clean sand and sand mixed with clay. They use as high

as 12 per cent. of clay in their mixtures, and obtain better results than with the clean sand. Besides, with the clean sand you may use more cement. In Germany the laboratory of the German Cement Manufacturers' Association made tests of clean sand, of sand reduced to a fine powder and also of ground iron ore. They found that the clean sand was good, powdered iron ore gave a higher result, and powdered sand still higher. Therefore, I do not believe in clean sand.

MR. B. K. KRAMER:—I would like to ask if there is not a difference in clay? There are some clays, perhaps, which would give good results, while others might not.

MR. SEAFERT:—The Chicago, Milwaukee & St. Paul Railway uses the clay with the sand as it comes out of the bank. They had some that contained vegetable matter that was not as good. If the pure clay is mixed with the sand it is no injury to your concrete.

PRESIDENT HUMPHREY:—Mr. Matcham, we would like to hear from you on this subject.

MR. MATCHAM:—I can only say that I have never known that clay would be of any benefit to concrete. It is something entirely new to me. In examining sand for concrete where we find there is clay present we always contend that it is detrimental, and that the sand should be clean and sharp.

MR. SEAFERT:—Have you ever made any comparative tests of such sand?

MR. MATCHAM:—We have made tests on the clayey sand and the clean sand, the sand washed and so forth, and we have obtained much better results from the clean sand than from the sand containing clay.

MR. SEAFERT.– I would like to ask the gentleman what his results were, and if he was certain that there was no vegetable matter in his clay. The Chicago, Milwaukee & St. Paul Railway Company have made tests of the sand along their road, and they found some clayey sands containing vegetable matter, which did not give desired results. They have found others that contained no vegetable matter, and this made so much better concrete than that obtained by using clean sand that they are now using clayey sand wherever they can obtain it. You must get rid of the vegetable matter in the clay if you want good results.

MR. MATCHAM:—What would be the result of 10 per cent. or 12 per cent. of clay added in a sand in making concrete block, what kind of colored blocks would you get?

MR. SEAFERT:—That would give you a uniform color and would give you a denser, more water-proof block. Clay is simply finely pulverized sand.

MR. MATCHAM:—Mr. Seafert, if you had 8, 10 or 12 per cent. of clay in your sand in making the concrete blocks it would certainly be detrimental; it would interfere with the removal of the blocks from the molds and would retard the set; it is known that the clay retards the setting of the concrete and therefore your concrete block would be very much longer in getting its strength with so large a per cent. of clayey matter.

MR. SEAFERT:—That all depends upon what kind of cement you have. If you have a cement that will set in 24 hours you will have no trouble, and besides it will benefit the ordinary cement made to-day that contains a very little free lime because the clay will neutralize it.

MR. MATCHAM:—Take the well-setting Portland cements such as are exhibited here. These are the kinds of cement we use. We want a cement that is well balanced and that will harden properly.

MR. TURNER:—I think it is a fact that a small amount of clean clay may add to the strength of concrete, but personally in executing the reinforced concrete work, we prefer to see no clay in the sand, for the reason that you may get mud of any kind in your mixture in place of clean clay, and it is much harder with dirty material to form any idea whatever as to how much cement it will take. We are using nearly all grades of gravel, and while we cannot in many cases attempt anything in the way of a scientific analysis of the materials used, we do vary the amount of cement as much as 40 per cent. in an effort to get a fair degree of uniformity in the resulting concrete. If the engineer or the architect should allow a contractor to adulterate your sand with clay or any other material I think it would be a very unsafe policy. At least I would not agree to assume the responsibility for it. Speaking of aggregates in general, the strength of the mortar uniting the coarser material in the ag-

gregates will very largely determine the resulting strength. In other words, if we have the aggregates graded in size so that the amount of voids is reduced to a minimum, an thed quantity of cement to fill the voids is also reduced to a minimum; if you use the same amount of cement and have the same amount of voids in any other aggregate you will get the same strength.

MR. SEAFERT:—How is it with the silica cement, which contains 50 per cent. cement and sand? Is its use not proof that a mixture of silica is of benefit, or at least does not injure the Portland cement? It fills the voids. Now the reason that you do not use silica cement is because you have got to take the manufacturer's word for it that he has got 50 per cent. Portland cement and 50 per cent. ground silica in with it. An engineer questioned me on this subject some time ago, and I told him that unless he knew what the cement contained he was taking great risks.

MR. KRAMER:—I would like to ask whether climatic conditions have anything to do with the use of cement?

PRESIDENT HUMPHREY:—I will call on Mr. Pierson for an answer to that question.

MR. A. N. PIERSON:—I feel very certain that the climatic conditions surrounding the curing of the work, concrete blocks, reinforced concrete, etc., have a very great influence on the character of the resulting product. For instance, it makes a great difference whether we have a driving wind sweeping over concrete blocks or whether they are housed where the atmosphere has a reasonable degree of dampness, where the blocks can obtain a small amount of moisture from the air or from the damp ground directly under the blocks. That is true in all manner of concrete, for we see the sidewalk men covering their work for from three to ten days according to the conditions of the underlying soil, and also according to the condition of the atmosphere and of the temperature. We know that during the summer months we must use more care and prepare our work for a more rapid setting than in winter. These are two distinct classes of work, and a definition can hardly be given to cover both. For the ordinary dry mixture there is no question that the atmospheric conditions and the thermometer play a very large part. In order

to get good results a moist atmosphere, which can only be obtained by the use of plenty of water, must be maintained about dry mixed work.

MR. JOHN DRISCOLL:—Mr. Seafert objects to fine dust or powdered crystalized limestone as it comes from the yard crusher. Does he not consider it better and safer to remove that dust? Is that preferable to clay? Clay, in order to be adapted to use, must be pulverized. We find that in Wisconsin it comes in small chunks, which are so hard that they do not break up with the tamper, and while curing or when exposed to the weather it leaves holes. My experience is that the finer and cleaner we can get the limestone the better will be the results in the manufacture of blocks.

MR. SEAFERT:—The Illinois Tunnel Company of Chicago, who built 32 miles of tunnel, started in with crushed stone, using it just as it came from the crusher, and for the first year it showed up wonderfully well. They made careful specimens of the crusher-dust. Up to the first year crushings from their limestone ran much better, but at the end of the year the limestone gradually decreased; they finally substituted bank sand which gives better results and has more waterproofing properties than the crushed stone simply because it makes a denser concrete.

MR. E. S. HOTCHKISS:—I think the gentleman that has just spoken stated his case well, but there is another side to the matter, and that is the dry mix, and I have been working for two years wholly with crushed limestone, and I find that the dryer the stone is and the more it goes over the screens the better it is. On a damp day when this stone, which we use for the aggregates, catches up the little fine dust from the crusher it does not make very much difference how much you mix it, it still adheres to the stone. Now, the cement surrounds but does not coat the stone because it is covered with this dust. We find that it makes a very much better concrete if that stone is thoroughly washed and is thoroughly dry, than it does to use the damp stone with this fine dust adhering to it and not having the chance to mix with the cement.

PRESIDENT HUMPHREY:—I think there has been some confusion created by the term "clay." Now, as we ordinarily

understand clay, it is a material such as bricks are made of. A putty-like material. The clay that Mr. Seafert and some of the other gentlemen have been referring to is of a wholly different character. Clay is generally formed by the decomposition or the breaking down of feldspars or more particularly orthoclase. In the process of decomposition it often happens that the fine material that is found in fine clay and sand is of a very distinct character and grades from a very coarse down to a very fine material. The tests that have been made on material of this character seem to show that a very fine material, such as would pass a 200 sieve, or the material that would float when agitated with water and which should be called silt and not clay, when present in percentages not more than perhaps 6 per cent. does not have a deleterious effect on the aggregates for concrete, but by reason of its filling the voids, enhances the strength of the material. Of course where this occurs in lumps it is not desirable and on the contrary very objectionable. A great objection to an excess of extremely fine material is that it fills the pores in the larger aggregates, thereby preventing the cement from getting in, which materially reduces the bond, and, therefore, the strength. Besides bank sands and gravels which contain clay may have considerable vegetable or organic material, which very greatly reduces the strength.

MR. KRAMER:—Would it not be preferable instead of using the clay to use hydrated lime? Would it not make the concrete more compact or just as compact and the result would be better than to use clay?

MR. CHARLES MANKEDICK.—I have had considerable experience with different sands. I have used sand that was absolutely pure, washed out, and have used sand from the pit where the covering soil came down. The trouble here seems to be that the clay and soil that drops down mixes with the fine sand. We have used sand just as it came from the pit, with balls of clay in it, and through the winter months they would freeze in the block and cause trouble. We have screened that sand and obtained better results. It gave the finest and densest blocks we have ever had. We have also used this sand for cement walks.

MR. JOHN W. DICKINSON.—The gentleman has referred

to hydrated lime. I suppose a certain percentage could be included in the concrete, but you have to keep the price of this work down to a minimum, and the addition of this material increases the cost. It has been my experience that sand should be well sifted, for the finer the sand the better it will fill the voids. Clay is also added only for the purpose of filling the voids. But how much should be added? In block manufacture and in sidewalk construction, the determination of strength rests largely on laboratory tests of mortars and concretes, and these results, I think, will show conclusively that the addition of a small amount, well distributed, is a help. If we could have an ideal sand with the finer portion of it passing the 200 sieve, and a certain other portion passing the 100 sieve, and from these up to a coarse sand that itself furnishes the fine matter, then the question would be entirely solved, but in the absence of finding that ideal sand, I feel convinced that the addition of a certain amount of soil, whether we call it clay or any other matter, is an improvement.

MR. M. S. DANIELS:—The question has been raised as to the use of crusher dust. I have had a little experience along that line and have had some laboratory tests made primarily for the reason that the sand we had to use was very fine. We used three grades of sand, but I only want to speak to you of two grades. Of our coarse sand a large proportion will pass a No. 100 sieve, and a considerable quantity of what we call our fine sand will pass a No. 200 sieve. With the use of the same cement, the same length of time for cure, and tested in compression at the same age in the same machine, we have found the following results: with our coarse sand a compression of 1,808 pounds per square inch was obtained; with our fine sand 1,025 pounds per square inch. Now, by the addition of the crusher dust as it comes from the crusher and as it went through the screen having one-half inch holes, and by actually sifting thereafter what passes a No. 4 screen, we have had this result: with the 1:2:3 for the coarse sand, 1,250 pounds per square inch. We have taken and measured by mortar tests the crusher dust and have found as nearly as we could get at it that for every four feet of crusher dust we have had to add 1.2 feet of sand. The coarse sand then gave us 2,933 pounds per square inch, and the fine sand

3,442 pounds per square inch. The fine sand, by the way, is said to hold an excess of clay. I think, in the neighborhood of perhaps 20 per cent., although no analysis of the clay has been made. The sand is common bank sand, but the result seems to indicate that a very fine sand mixed with crusher dust in proper proportion will increase its strength somewhat over three times.

MR HOWARD G. GOODWIN:—A practical experience in the concrete block business in the last few years proves the remarks of the last gentleman. Using common bank sand, and I would say that the ordinary bank sand, as one of the gentlemen has remarked, is not the ideal sand, we find all sizes and all grades of sand from the finest up to sometimes gravel. Now, the object in a commercial way in the block business is to make a good block at a price that is reasonable. One of the practical results that we have found is this, taking a mix of 1 to 3 with a fine ordinary bank sand, I find that a better block can be made at less than one-half the expense by grading the sand. I mean by that, screening and separating fine sand in one pile, coarse sand in another pile and gravel, say from one-quarter to one-half or three-quarters of an inch, in another pile; then proportioning, say 1 of cement, 1 of fine sand, 2 of the coarse sand and 3 of the gravel. I find this mix to give a stronger block than a mix of common bank sand of 1 to 3, and I find that I save thereby more than one-half the cement. In addition it gives a denser and therefore a more water-proof block.

MR. JOHN DRISCOLL.—I would like to say a few words about the effect of climatic conditions on cement. In hot weather I have laid sidewalks which set so rapidly that you could walk over them in the evening, and I claim that it is just as good a walk as one laid during cold weather and covered with moist sand for three days so that it will harden slowly for a week. Perhaps some scientific man here can explain how or why it makes the difference. Any man that has had experience in sidewalk laying knows that it is just as good as the one protected by water and protected from the rays of the sun as the specifications require.

CEMENT AND BUILDING CONSTRUCTION.

C. A. P. Turner.

The members of the Cement Users Association may, with reason, congratulate the American Portland cement manufacturers on the uniformity and reliability of their product. They have reached this degree of perfection in their cement only by careful study of methods and materials used, combined with systematic tests of the resulting product.

The cement user may well profit by their example and s udy his methods in the use of cement if he is to produce results at all in keeping with the high grade and possibilities of the material he is using.

In foundation work Portland concrete is largely replacing footing stones, giving a continuous monolithic construction which, where the ground is soft, may be readily and cheaply reinforced with rods, and where the conditions are still more unfavorable and piling is used, a concrete cap reinforced has evident advantages over timber.

In placing the material it may not be amiss to suggest to those who expect results without attention and care on their part, that failure to properly mix the materials and depositing the concrete haphazard without consolidating it by tamping and puddling, or allowing mud and sand to flow around the several shovelfuls or barrelfuls deposited, will quite likely result in a footing of little more value than one the writer was forced to remove from under a reinforced column five stories high. The contractor, who appeared careless to a reckless extent and thoroughly incompetent, rather than dishonest to this extent, stoutly asserted that the mixture was according to specifications and the pier according to plans. When clamps were put on the column and the footing removed, bad cement was the excuse. The idea that bad workmanship and the lack of cement had anything to do with it, seems not to have occurred to him, although in removing the material, a pick could be driven into it half the length of the

blade and streaks of sand and clay unmixed with cement could be found in nearly every sample.

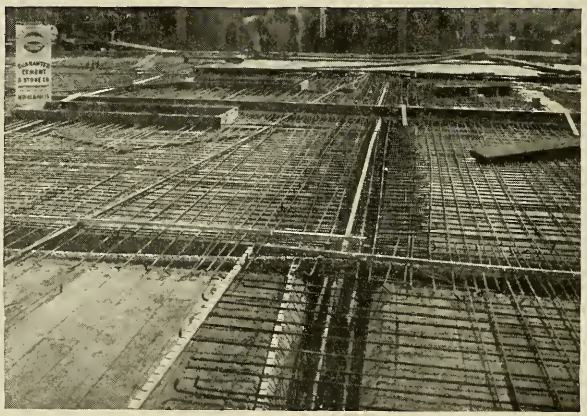
In exterior walls of concrete, many depend for finish on a plaster coat after the work has hardened. Wetting the walls thoroughly sometimes enables a sound coat to be applied, though often there is scaling and chipping when the work dries too rapidly. Removal of the forms early, and rubbing down all inequalities before the work has hardened, may obviate this difficulty.

As a cheaper form of construction, cement brick and concrete blocks are coming into use. The general prejudice against this type of construction among architects can readily be accounted for. Too many block manufacturers believe in mixing their concrete 1 cement to 7 or 8 gravel, and selling it for a 1 to 3 mixture. Then again through the unfortunate fad of imitating rock faced stone, our concrete block friends must be credited with the production of the most monotonous building material ever placed on the market.

Too little attention seems to be given to artistic effects that should readily be obtained in the manufacture of blocks at a comparatively insignificant increase in cost. The practice of facing with a selected material such as fine white sand or crushed marble or granite with a rich mixture of cement seems to have been done only to a very limited extent, while as a matter of fact, it is practical and comparatively inexpensive. By casting the faces downward, the facing may be made thin and quite dry and the backing wet enough so that it will supply the necessary moisture to properly crystallize and harden the dryer facing. The object of making the facing dry is, of course, so that it can be removed from the mold without sticking to it and destroying the finished surface, which would be the result using a wet or moist mixture. By a dry mixture the writer does not refer to one which is mixed without water, but to one that is not sufficiently wet or rather moist, to stick to the plates of the machine when tamped.

The writer's observation of the manufacture of cement brick, is that by the use of a dry facing of fine white sand mixed in the proportion of 1 cement to 2 sand, averaging a quarter of an inch thick, backed by a mixture of 1 cement

to 4 coarse sharp sand made wet enough to stick together when a sample is squeezed between the thumb and finger, very satisfactory results were obtained and with no trouble in curing. On the other hand, such a mixture would force the workmen to wipe the division plates of the machine every second or third batch, and they were too much inclined to save themselves this trouble by using a dryer mixture which could be cured, if at all, only with difficulty and repeated wetting. The difference in the amount of moisture in the two cases is slight, but the difference in the product at the end of twelve hours is very marked. At the end of that period, the brick made with a moist backing would

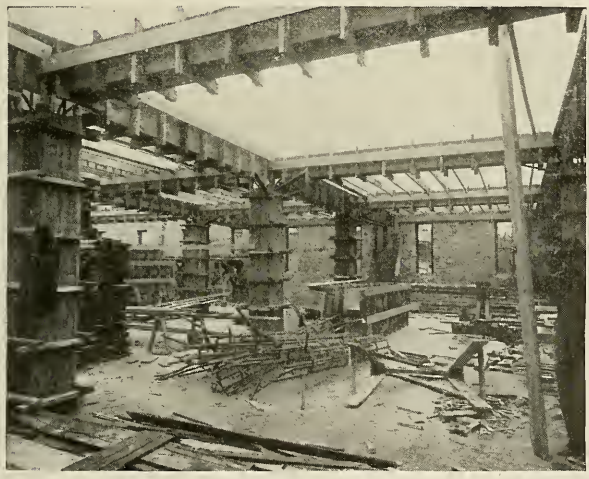


set so that the corner would have an edge sharp enough to cut the skin of the finger if rubbed along it and if the brick were thrown against a hard block it would break into fragments like a burned brick. On the other hand, in one made with the dry backing, the corner could be readily sanded out and if the brick were treated as the other, there would be nothing but sand left.

It may be imagined by some that there would be a plane of cleavage between the rich facing and the leaner backing, but in no case has the writer been able to break the facing away from the backing, cleavage occurring in all cases either one side or the other of this plane.

The cement bricks, with which the writer has had ex-

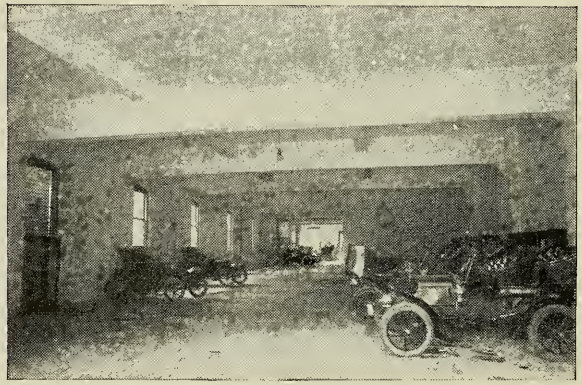
perience, unless of considerable age, do not stand shipment well. Better methods of curing will undoubtedly remedy this and seem equally applicable to the block business. A warm, damp atmosphere is most conducive to the hardening of concrete and it would seem that a curing chamber in which the blocks and bricks could be placed and subjected to an atmosphere of exhaust steam, would be an ideal arrangement. To properly realize the possibilities in this line of work, evidently requires honest and thorough work combined with a careful study of methods and results and when this is fully realized by those engaged in this line, we may expect the architect will be ready to favor the material which you have



demonstrated, to be strictly high grade. This demonstration, however, must come from the manufacturer, as he cannot consistently expect the architect to specify something which might be satisfactory if the work was well executed, with the chances against this being realized.

In interior construction the advantage of concrete properly reinforced, over timber or steel, lies in its permanence, the perfect protection of the steel against corrosion or destruction by fire, and last, but by no means least, to the peace of mind of the builder, the avoidance of complicated shop details and the opportunity for the annoying little errors and endless delays incident to structural iron work.

In treating the subject from the popular standpoint, the writer would say a few words as to the reliability of the construction as compared with steel or timber. Ignorant abuse will render dangerous the best material the engineer uses. For example, some months ago the writer was called upon to inspect some coupler pockets forged out of 10¼-inch by 4-inch bars. They were worthless, the writer was told, and going to the pile and selecting four, they were placed on the ground and struck a few sharp blows with the sledge. A single blow fractured 10 square inches of metal in two cases. In normal condition this area would carry 600,000 pounds in tension. Taking the shank to a steam hammer,



the center was bent flat on itself without fracture, proving that the smith had burned the steel in forging until it was worthless at the bend.

Similar inexcusable ignorance in working concrete will likewise result in inferior work, but by no means to such an extent as that instanced in the case of the steel.

While the use of reinforced concrete is older than steel construction, it is only the low price of Portland cement that has brought it rapidly to the front. During the time that cement was expensive it was naturally used sparingly, and it is a fact that this custom has had an unfortunate influence in the introduction of reinforced concrete. The use of too weak a mixture and the consequent failure to secure the requisite adhesion of the steel to develop the limited strength of this concrete has

brought out a number of deformed bars, the advocates of each claiming special merits.

As regards the question of adhesion, I think a few words may not be amiss. During setting the concrete shrinks, and this exerts a severe pressure on the bar. Now the intensity of this stress depends on the richness of the concrete. With a weaker mixture, of course, we do not get this bond between the steel and the concrete, and it makes no difference whether we are using a plain bar or a deformed bar, as far as pure adhesion is concerned. Again, where the bar is of irregular form this shrinkage strain produces unequal stress on the concrete and it would seem logically to be a sort of weakness. The circular form of the bar would seem to be the ideal in this respect. Now, in the distribution of the metal through the concrete we must have it disseminated through the mass. We cannot lay the bars down alongside of each other and get the best results. In taking care of the stress and tying the building together with continuous construction these bars must be bound, whether they are deformed or plain, and, as I look at it, the bars, if they follow the lines to secure the maximum strength, will get all the anchorage that is necessary. The condition of the concrete, where it is submerged is not as favorable to this bond between the concrete and the steel. Whether we should treat it differently is perhaps open to question. Another claim that is generally made for the deformed bars is that in case the work is overstrained it will be less damaged if we have this mechanical bond. This may be open to question logically for the reason that there is ample experimental evidence to show that concrete will flow a certain amount, as indicated by Prof. Woolson's tests, and it becomes then a question as to how the deformations in the bar will act, whether it is not preferable to allow the concrete to flow with the bar, with perhaps a certain amount of displacement occurring and still have the concrete intact around the bar, or have it sheared and broken in detail by such deformations as are used.

There is another point which I do not think has usually been given consideration. We have the evidence of Mr. Considére, showing in his experiments that the concrete, when the reinforcement was disseminated through it, could be deformed

much more than when used alone. His test pieces were small and the bars were close together. We have Professor Turneaure's work, which is equally creditable, showing that there were hair cracks in his concrete under comparatively low working stress. If reinforcement enables the concrete to stretch in the vicinity of the reinforcement, there is a logical question as to how far through the concrete this influence will extend. There must be a limit, and we must take into consideration the evidence on both sides of the question if we are to proceed in a rational manner in our designs. I am ready to accept the evidence of both scientists and be governed accordingly, and am ready to look for new information on that line as it may be developed in tests.

I have already called attention to the effect of variation in richness of mixture. The concrete samples put up by Considére were probably of a very much higher grade than the concrete experimented on by Professor Turneaure. The published tests showing the roughness of the specimens do not compare favorably with the work that professional concrete men are executing every day, and conclusions drawn from them will not be applicable to the better work. All of those things we must take into consideration to arrive at a true and fair understanding of the work.

As the writer has secured, as far as he is aware, greater strength in actual construction with special arrangements of plain bars, than anything claimed by the advocates of special bars, he is inclined to regard the advantages claimed for them as a somewhat imaginary quantity. In designing the reinforcement of beams and slabs, advantage should be taken of the principles of continuity, since with constant section we have to provide for only two-thirds of the moment of a simple beam and we have but one-fifth of the deflection. Further, by properly lapping the rods we may double the section over the support and require theoretically but half the metal necessary for a simple beam the same strength. This system of design calls for the major section of metal for the flange reinforcement over the support and furnishes ample provision for shear.

In constructing work in this line, it is well to bear in

mind that centering is a considerable item and that each additional beam is an extra expense. This fact led the writer to use larger and larger slabs, and finally to advocate construction of floors with column spacing 16 to 18 feet centers with no beams whatever, but simply a plain slab and columns. In this connection a few remarks regarding the theory of reinforced concrete may not be amiss. The theory based upon the elastic properties of the dual material has been derived from experiments on beams and slabs reinforced in one direction and agrees fairly well with the results of tests of work involving the conditions considered in this theory.

The conditions resulting from reinforcement in a number of directions are, however, not properly considered in any work that the writer is familiar with. Mr. Chas. F. Marsh makes this statement in his work on reinforced concrete, part 5: "Unfortunately it cannot be said that we have a thorough knowledge of the properties of reinforced concrete. It may be that we are wrong from the commencement in attempting to treat it after the manner of structural iron work and that although the proper allowance for the elastic properties of the dual material is an advancement on the empirical formula at first employed and used by many constructors at the present time, yet we may be entirely wrong in our method of treatment. The molecular theory, that is, the prevention

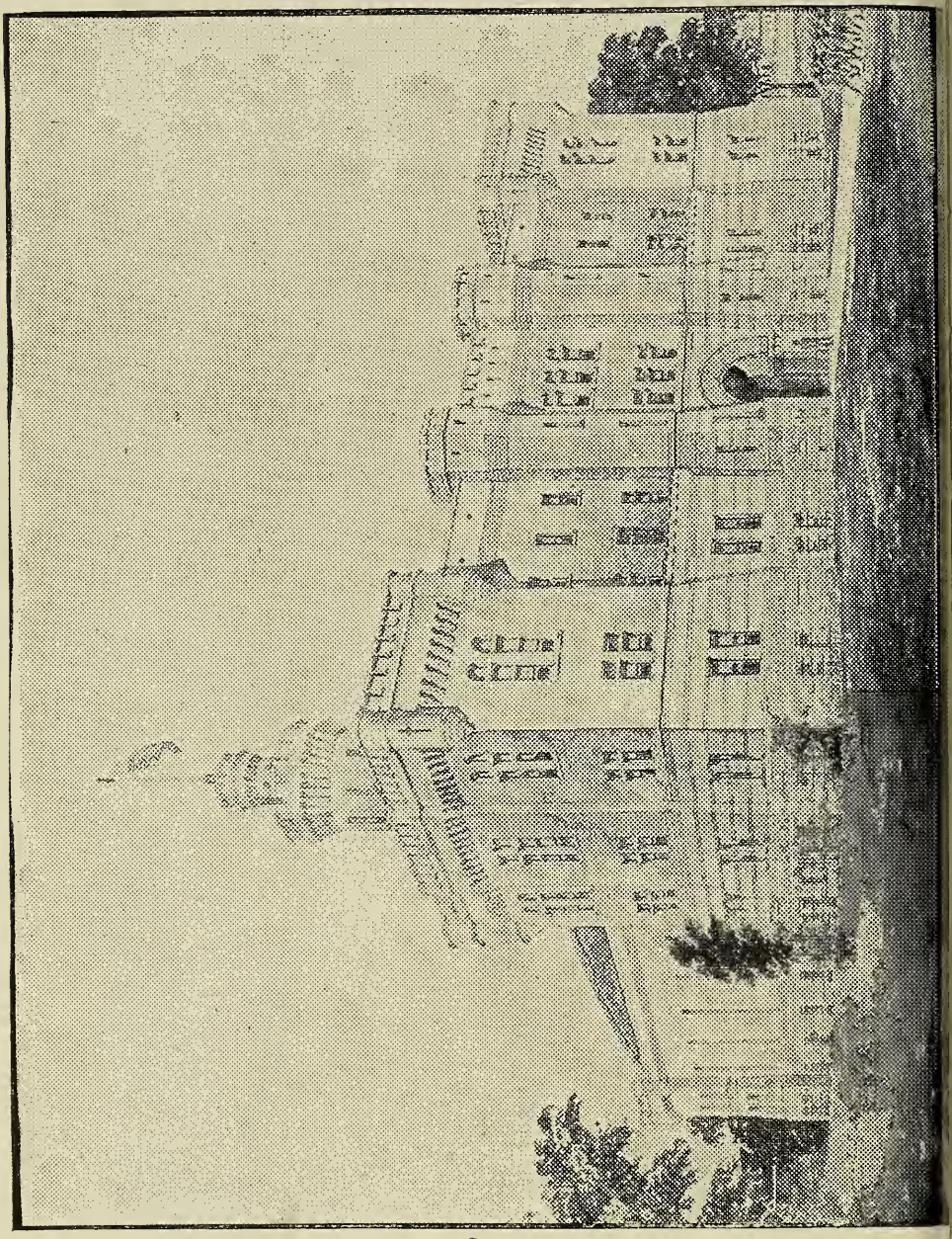
of molecular deformation by supplying resistances of the reverse kind to the stresses on small particles, may prove to be the true method of treatment for a composite material like concrete-metal. This theory is the basis of the Cottancin construction which certainly produced good results and very light structures, and Considére's latest researches on hooped concrete are somewhat on these lines." As the writer has been able to place a test load on slabs equal to two or two and one-half times their figured ultimate strength by the formulæ presented in Mr. Marsh's treatise, without injuring

the construction nor apparently developing more than a third its ultimate strength, he is inclined to agree with Mr. Marsh and is in the habit of designing these slabs and guaranteeing them, not on the basis of text-book theories, but by the known relation of the new slabs to the slabs tested as regards the depths and the moment of the super-imposed load.

As regards the materials for our aggregate, as a matter of economy we use either crushed stone and sand or sand and screened gravel without screening. In crushed stone, the harder the stone the stronger our concrete. For reinforced work we use a mixture of about equal parts of sand and crushed stone ranging in size from a pea to ⅝-inch or ¾-inch

diameter and about 1¼ barrels to 1½ barrels of cement to the cubic yard of concrete. For columns we find it cheaper to secure the compressive strength by the use of a rich mixture from 2 barrels up to 2½ barrels per cubic yard. We can depend on such concrete showing a crushing strength in cubes upwards of 6,000 pounds per square inch and can readily keep the size of our columns to reasonable dimensions with ample strength. The system of reinforcement that we use consists of a fair percentage of vertical reinforcement used for columns with riveted hoops at intervals of the length. Where we do not employ beams, we bend the vertical reinforcement outward, making an enlarged cantilever top to the column, which is buried in the slab and supports the slab reinforcement, and we reinforce the slab in four directions. Where we employ beams, we prefer to break the floor up into panels, rectangular and if convenient, approximately square, and reinforce our slabs in two or more directions. If we are using gravel for the aggregate, we sample this carefully and vary the amount of cement, dependent upon the character of the material. If the gravel contains some clay and considerable finer material, we use a larger percentage of cement, endeavoring to get practically the same results regardless of the composition of the aggregate. Many have the idea that crushed stone has some peculiar advantage over shingle or the round stones that we find in our gravel. The results of a series of quite comprehensive tests made at Duluth by the Great Northern Power Co., were kindly furnished the writer by Mr. D. A. Reed, their Assistant Chief Engineer. The mixture as I recollect, was practically a 1-3-5. The aggregate was crushed shale rock first, second, crushed Duluth granite, and third lake gravel. My recollection of the percentages of these tests is that the crushed granite, which is practically a hard trap rock, only showed a little over 90 per cent. of the crushing strength of the gravel concrete, and that all the results seemed very saitsfactory, running from 3,200 to over 4,000 pounds per square inch.

In mixing the material, enough water should be used for reinforced work so that the mixture should have the consistency of brick mortar and flow slowly to fill the molds. No tamping should be required, but even with this mixture



a certain amount of puddling and jarring or shaking the reinforced rods is desirable if the best results are to be secured. Where practicable, as much of the work should be run in at the same time as possible, since a beam or a slab which is spliced will show much less stiffness than one which is cast at one time, a condition that can readily be accounted for by the shrinkage strains in the concrete.

A question which is quite frequently raised and concerning which many architects seem to be worried, is whether reinforced concrete can be successfully executed in winter. In engaging in this business, the writer will say frankly that this question gave him some little concern. His previous experience in building bridge piers when the temperature was at times 25 and 30 degrees below zero, caused him to consider it practicable to execute reinforced concrete work in the winter and we are now carrying it on every day just as we would in summer, except for the slight inconvenience that we have to keep the snow and ice out of our forms until we can fill them with concrete, and are obliged to heat the material that we use. When this is properly done, freezing does not appear to damage the work as much as too rapid drying in the hot summer months.

We have here a number of views of work that we have executed, some showing test loads that have been applied. We have put up nearly all kinds of structures—office buildings, machine shops, warehouses and paper mills, and the writer has recently designed some reinforced concrete for a large power station in which there are to be three of the largest vertical generators that have been built, having a capacity of 7,500 kw. with 25 per cent. overload. These are to run at the rate of about 380 revolutions a minute and are to be supported on a reinforced concrete slab of about 21 feet span.

DISCUSSION.

MR. TURNER:—Regarding the rock faced block, I think the worst criticism that can be lodged against them is the monotonous repetition of the same thing over and over again in their use for constructing a building. Concrete is a material which is good enough so that it is not necessary to imitate a roughly chipped stone. Perhaps an occasional rough block on the corner of a building which is built up and faced with a nice, clean, well-finished block, might add to its architectural appearance, but certainly, I think, an effort should be made by the block men to draw a line on the monotonous building of a wall in which every block is just the same, and has just the same rough surface of the same size, and on the whole is nothing but a monotonous string of the same material, having no beauty, and costs even more than work which would look far better.

MR. SEAFERT:—I believe the object of the rock face is to get uniformity and prevent local discoloration, while the smooth faced block is never uniform in appearance. Unless you rub it down with a steel brush you will have a coarse appearance and hair cracks on the face. The rock face finish overcomes that.

MR. TURNER:—I know from experience that if the suggestions made in that paper are followed out in facing the blocks there will be no hair cracks.

MR. DANIELS:—I would like to inquire whether I understood the reader of the paper to say that in laying a reinforced concrete floor, he would lay it in sections, or would he lay it in the monolithic form?

MR. TURNER:—As far as we are able, we put it in monolithic form. In other words, in the building which we illustrated we could get in a half floor in a day, columns, beams and slabs all worked continuously. We work the whole thing at once. In splicing I prefer to put in a four-corner, as far as the slabs are concerned, making a cut in every beam, if we are using beams.

Mr. Rudolph P. Miller:—I would like to ask Mr. Turner what he considered in making the load test on these floors, the proper load to apply, and what maximum deflection should not be exceeded under such loads. There is a practice in some sections of the country of loading to three times the proposed working load. Now, it would seem that this approaches, in ordinary designs, the elastic limit of the metal, and might necessitate tearing out and rebuilding the floor, which would be a difficult undertaking, so what is a fair load to put on such construction?

Mr. Turner:—The question of deflection depends on the depth of the work. For instance, with a deep beam or girder you would have a smaller deflection than with a shallow beam. Owing to the peculiar characteristics of reinforced concrete, to set a limit, or to specify what the exact deflection should be, is something which I regard as difficult. In other words, I would not be willing to guarantee a deflection in every piece of work which I have constructed with tests of work which have been cast in monolithic form. Take the beam in that test of 160 tons, the central beam 21 feet, 6 inches, the cross beam 12 x 16 inches in section with a 6½ inch slab above. By setting a standard below it and measuring the deflection as carefully as we could we found it so small as to be almost inappreciable, certainly not exceeding a 1/64 of an inch. The beam next to it, which carried not over two-thirds of the same load, however, showed a deflection of 1/16 inch, due to the fact that there was a splice in the work on that beam and none in the other. In slab work it is always safe to guarantee that your deflections should not exceed that of a steel beam strained to the same amount as the reinforcement and equal in depth to the distance from the center of the reinforcement to the top of the slab. That is certainly conservative and in general, will not damage the concrete if it is well made; but there are very few cases, as I say, where the work is placed in monolithic form, that will even approximate that deflection. In the first test that I illustrated here, the slabs were 16 feet 8 inches in one direction, center to center of columns, and 15 feet 5 or 8 inches in the other, with the slab 5¾ inches thick. We had a slab deflection of about 5/32 inch, and in the center

of the beams approximately 1/16 inch, perhaps a little less rather than greater; so you can see the deflections were very small. On the other hand, the deflections in a 20 foot slab which was about 7¼ to 7½ inches thick and was made against my instructions on a sort of a patchwork under 80 tons of sand was 9/16 inch. My experience has been that if the reinforcement were in one direction only the deflection would be greater.

Mr. Daniels:—In laying such slabs, how much more than the working load was put on? Many eastern companies in their specifications guarantee their floor to stand a load of one and one-half times the proposed working load and the deflection to be not more than 1/600 of the span.

Mr. Turner:—I should say that any one ought to meet that specification readily.

Mr. Daniels:—Do you think that is sufficient?

Mr. Turner:—I think that is what will come to be accepted if we are not to expect more of concrete construction than we do of any other type of construction. You take timber construction, it will generally be more or less damaged by anything over one and one-half times the rated load. I am very well satisfied that if the building laws of a city like Minneapolis were enforced and if the floors were actually loaded for their capacity there would be chances for trouble.

Mr. Condron:—Something has been asked about tests on floors, and I would like to describe a test which was made sometime ago in Chicago on a floor somewhat similar in dimensions to what the speaker has described. These were floors in a building sixteen stories high and designed for a working load of 300 pounds to the square foot. The columns were 15 x 15 inches. The supporting girders ran in only one direction, the columns being tied together in the other direction by simple light beams. The owner of this building insisted that at least two columns in the floors should be tested to four times the working load, 1,200 pounds. He agreed that if it fell at 1,201 pounds to the square foot he would pay for the expense of replacing; if it fell anything short of 1,200 pounds the contractor was to stand the loss. The lowest bidder on the work refused to put in the work on that specification. He offered to do it at a load of 800 pounds

to the square foot. Finally one of the contractors agreed to do the work. After the building was put up they began to test on two different floors. The test required six carloads of pig iron for one floor. And the pig iron covered the entire surface 15 feet square, and gave a load of 1,200 pounds to the square foot. The floors, as I say, were designed for 300 pounds working load, practically weighed 100 pounds to the square foot, so that there was an actual load of 1,300 pounds, which was within 300 pounds of the theoretical limit of the floor. It is very gratifying to the contractor at least that there was absolutely no sign of injury apparently, to either one of the two tested floors, nor did the deflection exceed an inch in either case. I do not advocate the reinforcement of such floors in only one direction. The thickness of the inside was eight inches and the reinforcing bars ran in only one direction, three inches apart; and in the other direction were temperature rods two feet apart and not supporting any considerable part of the load. There are other floors with which I have been somewhat familiar whose design was somewhat similar to this, calling for a working load of 200 pounds to the square foot, and tested to 600 pounds to the square foot, without any sign of injury whatever, and as you are all aware, it has been quite customary to test the reinforced concrete construction to three times the designed load, which does seem to any one who has been familiar with the testing of other materials rather excessive; especially where such a floor is to be used afterwards. It is all right to build a section of a floor simply for test purposes and test that in that way, but it is not wise to load with such an excessive load and then continue to use the work.

While I am on my feet I would like to make two comments on Mr. Turner's paper. He has laid stress upon the fact that there is shrinkage in concrete setting, with which we are all very familiar, and that frequently increases the bond between the reinforcing metal and the concrete. This is true especially where it sets in the building. Much work in which I have been engaged in the past two years has been railroad work, which is soon covered over and may never become dry. He has also called attention to the fact that the richer the concrete the tighter the setting on the

rods will be. But in all cases of large work we are fully aware that it is impossible to arrive at the ideal conditions everywhere. The concrete will not be of uniform richness, and sometimes therefore the shrinkage would not be as great in places where it should reach the most secure bond; and it is for that reason that there is a strong argument in favor of a bar which has a mechanical bond, because it tends to greater insurance of work that cannot be in all parts inspected for thoroughness and perfection of workmanship. The necessity for the shrinkage is not so great with a deformed bar as with the plain bar, perhaps.

I notice from the pictures on the screen here that they have used the method of turning up the ends of the plain bar, presumably for anchorage, and I shall simply call attention to the simple fact, that the greatest stress in the metal is at the center of the slab. We will assume that the working stress in the metal under load is 15,000 pounds to the square inch. And under these conditions I think every one will agree with me that the stress at the end is zero. Consequently how can the turned up end be of any account where there is no stress? If he wants to turn the end of the bar let him turn it up at the middle of the span, but not at the end where there is no stress. The turn will not become effective until the bar has slipped. It would be as sensible to put cover plates on a steel plate and to turn the ends of the cover plates over the end of the girder and leave them loose between.

He has also referred to some most remarkable experiments by Professor Woolson, which personally I have been hardly able to believe. I do not doubt them but they seem to me like wireless telegraphy; you know it is so, but when you come to argue it you cannot. I must say that while it may be an experimental fact that concrete after it has set will flow, nevertheless, it is a crystaline material, and our ordinary conception of it is that it is brittle, and so far as I am concerned, I do not dare to use the hypothesis of flow of concrete in designing a structure on which human life depends.

Mr. A. N. Pierson:—What was the age of the work when this 1,200 pounds per square foot load was put on it?

Mr. Condron:—About sixty days. The tests were to

have been made at the end of three or four weeks, but the great quantity of material which it was found necessary to procure caused the delay. And I want to say right here, as long as I am on my feet again, that I have no faith absolutely in evidence of this kind. It does not mean anything. You can build a brick wall 150 feet high, but you do not get the weight on the lintels. I do not know as there would be any particular objection to that and whether there was any object in it, as long as you have supported the outside supporting beams. To my way of thinking, the scientific method of testing is the only method that can be absolutely relied upon, because there the pressure of the side walls has no effect on the load, and that leads me to a question which I would like to ask Mr. Turner. I have understood that they are engaged in the building of grain bins in which the bottoms were designed to carry the weight of only a part of the material in the bins, this load being gauged to a certain distance from the bottom; higher than that given point the additional load exerts no pressure on the bottom.

Mr. Turner:—I would like to make clear that we have in Minneapolis a building inspector who is quite a genius in the way of testing. That gentleman always wants to see a load applied to the slab so that the load is a sheer load laid straight on the slab. He does not want you to go over the beam. He wants it all to go over the slab proper and just inside of the beam. In regard to the bins, as I have stated before, the theory of reinforced slabs is not fully developed. We have tried a dozen or fifteen different methods of reinforcement. The one shown is the only one of them we have tried by actual experiment to arrive at conclusions. We have not got far enough yet to formulate them definitely, but we are getting results, and we build a load sometimes two, two and one-half, and sometimes three and four times as much as the working load. We make very little difference between light and heavy construction.

Now let us come to the grain bin. For a bin of small diameter the pressure on the bottom will increase with an increasing height of material up to a point beyond which any additional material will not affect the pressure on the bottom, although it will increase the reactions under the walls. In our

tests of these floors, we pile sacks of cement up as neatly as possible, making no attempt at interlocking them as is the case in brick work, where the bricks are bonded and cemented together with mortar so that they form a little triangle, which acts as a flat-arch. In the design of reinforced concrete I fully agree with Mr. Condron when he says, that people are quite inclined to ask you to place a load on the structure, which would indicate that it could carry four or five times that load without any damaging effect. In other words, they ask an actual factor of ten or twelve on your concrete construction and expect without question a factor that is much greater.

Mr. C. J. Farrar:—I wish to ask for the benefit of those who have not been able to make a special study of this subject, if there are any practical formulæ which would enable one to estimate the strength without going into an elaborate study of the subject.

Mr. Condron:—Mr. Turner and I, in fact everyone who is interested in the business, can furnish reliable formulæ; formulæ which have been used successfully, perhaps; but they would not all be alike, and he could then exercise his discretion in their use. He can also check their reliability by examples of their application in structures already built, or he can check them by the results of scientifically made tests which are subject to an exact analysis. I have a little pamphlet containing formulæ based on the study that I have made of over two hundred tests of large sized reinforced concrete beams at various engineering schools or laboratories, and one or two railroad laboratories. Furthermore, I might suggest the book on concrete by Messrs. Taylor & Thompson, where he will also find formulæ.

CONCRETE BUILDING BLOCKS.

By S. B. Newberry.

In the industrial progress of this country there is no feature more remarkable and striking than the development which has taken place in the applications of Portland cement. Fifteen years ago the amount of Portland cement used for all purposes in the United States was about 2½ million barrels, of which four-fifths was imported from Europe. In 1905 the consumption exceeded 30 million barrels, a twelvefold increase, and practically the whole of this is of American manufacture. The first and greatest victory won by the new material was its substitution for block stone in masonry constructions, such as piers, abutments and foundations, and for flagstone in the laying of sidewalks. Then followed a multitude of lesser uses, such as sewer-pipe, tiles, fence-posts, curb and gutter, piles, and ornamental architectural work of every description. Reinforced with steel rods, cement concrete has come rapidly into use in the construction of complete buildings and bridges.

Having gained full recognition as a building material of the first rank in engineering and monumental architecture, Portland cement is now invading the field of dwelling construction. All but the more costly dwellings have, until recently, been built of wood, a material that has only the qualities of cheapness and convenience to recommend it, since frame structures are admittedly perishable, uncomfortable, and unsafe against fire. Lately, however, wood has lost even the quality of cheapness, and owing to the exhaustion of our forests has advanced fully fifty per cent. in price. This has been a great hardship to home-seekers, and has forced builders to look for some other material for dwelling construction. Happily, Portland cement comes to the front, as usual, to fill the want. The hollow concrete building block, *properly made and used*, forms an ideal material for the exterior walls of buildings, and this replaces the part which, in wood, most rapidly deteriorates from exposure to weather. Buildings constructed of hollow

concrete blocks are no higher in first cost than those built of frame, and are far less expensive in repairs. They have all the advantages of stone and brick in point of comfort, coolness in summer and warmth in winter, and in respect of beauty may at small cost be made fully equal to those of any other material.

Unfortunately, owing to poor workmanship and lack of artistic design, a large part of the hollow block buildings hitherto erected have fallen far short of the excellence above described. A multitude of men without capital and inexperienced in the use of cement have embarked in the business of block making, attracted by the glowing prospects of profits held out by the army of block machine agents. As a result, great quantities of inferior blocks, weak, porous and unsound, have been and are being turned out, and have been erected by careless and unskilled builders into defective and ugly structures. This state of affairs is an injury to competent and conscientious block manufacturers, and an obstacle to the adoption of a most excellent and promising building material. Blocks of first-rate quality can easily and cheaply be made, with small outlay for machinery, provided certain simple rules are intelligently followed. It is the purpose of this paper to state briefly the causes of faults in concrete blocks, and the precautions by which good and reliable work may be assured.

CONCRETE.

Concrete is an artificial stone consisting of coarse and fine fragments, such as sand, gravel and broken stone, united by cement to a solid mass.

The strength of concrete depends greatly upon its density, and this is secured by using coarse material which contains the smallest amount of voids or empty spaces. Different kinds of sand, gravel and stone vary greatly in the amount of voids they contain, and by judiciously mixing coarse and fine material the voids may be much reduced and the density increased. The density and percentage of voids in concrete material may be determined by filling a box of one cubic foot capacity and weighing it. One cubic foot of solid quartz or limestone, entirely free from voids, would weigh 165 lbs., and the amount by which a cubic foot of any loose material falls short of this

weight represents the proportion of voids contained in it. For example, if a cubic foot of sand weighs 115½ lbs., the voids would be 49½-165ths of the total volume, or 30 per cent.

The following table gives the per cent. of voids and weight per cubic foot of some common concrete materials:

	% Voids.	*Wt. per cu. ft.*
Sandusky Bay Sand	32.3	111.7 lbs.
Same through 20-mesh screen	38.5	101.5 "
Gravel, ¼ to ⅛ inch	42.4	95.0 "
Broken limestone, egg-size	47.0	87.4 "
Limestone screenings, dust to ½ inch	26.0	122.2 "

It will be noted that screening the sand through a 20-mesh sieve, and thus taking out the coarse grains, considerably increased the voids and reduced the weight; thus decidedly injuring the sand for making concrete.

The following figures show how weight can be increased and voids reduced by mixing fine and coarse material:

	% Voids.	*Wt. per cu. ft.*
Pebbles, about 1 inch	38.7	101.2 lbs.
Sand, 30 to 40 mesh	35.9	105.8 "
Pebbles plus 38.7% sand, by vol	19.2	133.5 "

Experiments have shown that the strength of concrete increases greatly with its density; in fact, a slight increase in weight per cubic foot adds very decidedly to the strength.

The gain in strength obtained by adding coarse material to mixtures of cement and sand is shown in the following table of results of experiments made in Germany by R. Dykerhoff. The blocks tested were 2½-inch cubes, one day in air and 27 days in water:

Proportions by measure.			Per cent. cement by volume.	Compression strength. lbs. per sq. in.
Cement.	Sand.	Gravel.		
1	2	—	33	2,125
1	2	5	12.5	2,387
1	3	—	25	1,383
1	3	6½	9.5	1,515
1	4	—	20	1,053
1	4	8½	7.4	1,204

These figures show how greatly the strength is improved by adding coarse material, even though the proportion of cement is thereby reduced. A mixture of 1 to 12½ of properly pro-

portioned sand and gravel is, in fact, stronger than 1 to 4, and nearly as strong as 1 to 3, of cement and sand only.

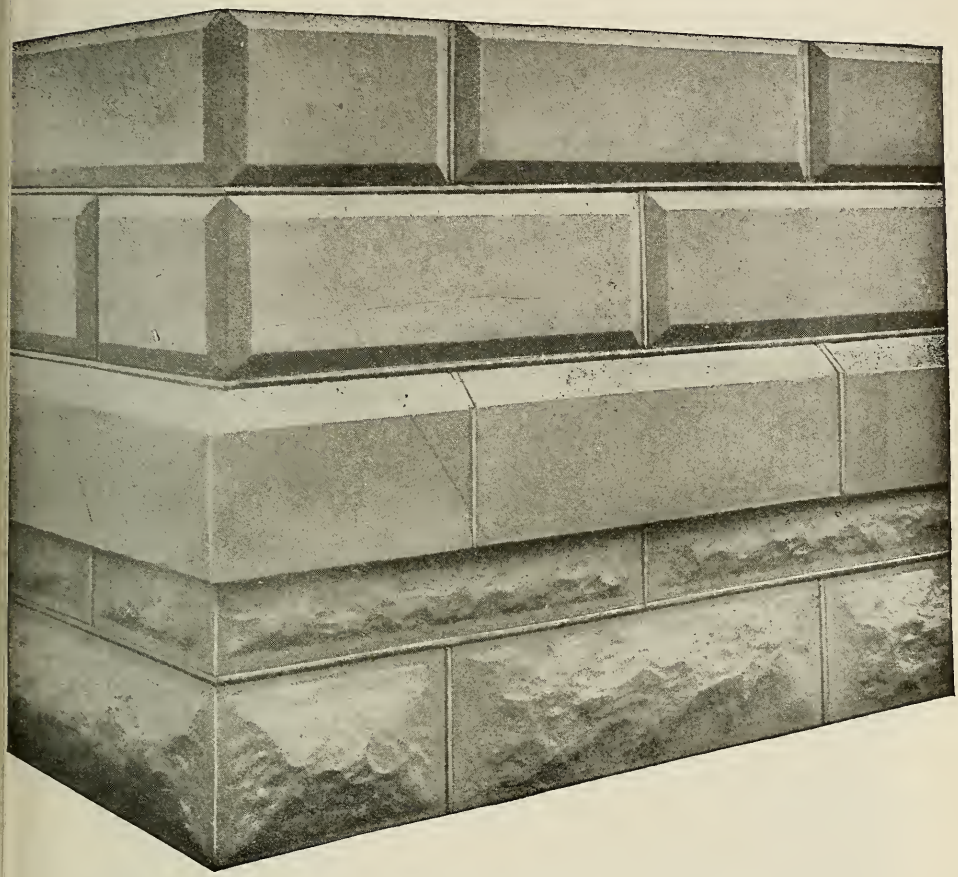
In selecting materials for concrete, those should be chosen which give the greatest density. If it is practicable to mix two materials, as sand and gravel, the proportion which gives the greatest density should be determined by experiment, and rigidly adhered to in making concrete, whatever proportion of cement it is decided to use. Well proportioned dry sand and gravel or sand and broken stone, well shaken down, should weigh at least 125 lbs. per cubic foot. Limestone screenings, owing to minute pores in the stone itself, are somewhat lighter, though giving equally strong concrete. They should weigh at least 120 lbs. per cubic foot. If the weight is less, there is probably too much fine dust in the mixture.

The density and strength of concrete are also greatly improved by use of a liberal amount of water. Enough water must be used to make the concrete thoroughly soft and plastic, so as to quake strongly when rammed. If mixed too dry it will never harden properly, and will be light, porous and crumbling.

Thorough mixing of concrete materials is essential, to increase the density and give the cement used a chance to produce its full strength. The cement, sand and gravel should be intimately mixed, dry, then the water added, and the mixing continued. If stone or coarse gravel is added, this should be well wetted and thoroughly mixed with the mortar.

MATERIALS FOR CONCRETE BUILDING BLOCKS.

In the making of building blocks the spaces to be filled with concrete are generally too narrow to permit the use of very coarse material, and the block-maker is limited to gravel or stone not exceeding ½ or ¾ inch in size. A considerable proportion of coarse material is, however, just as necessary as in other kinds of concrete work, and gravel or screenings should be chosen which will give the greatest possible density. For good results, at least one-third of the material, by weight, should be coarser than ⅛ inch. Blocks made from such gravel or screenings, 1 to 5, will be found as good as a 1 to 3 with sand only. It is a mistake to suppose that the coarse fragments will show on the surface; if the mixing is thorough this



will not be the case. A moderate degree of roughness or variety in the surface of blocks is, in fact, desirable, and would go far to overcome the prejudice which many architects hold against the smooth, lifeless surface of cement work.

SAND AND GRAVEL are, in most cases, the cheapest material to use for block work. The presence of a few per cent. of clay or loam is not harmful provided the mixing is thorough.

STONE SCREENINGS, if of good quality, give fully as strong concrete as sand and gravel, and usually yield blocks of somewhat lighter color. Screenings from soft stone should be avoided, also such as contain too much dust. This can be determined from the weight per cubic foot, and by a sifting test. If more than two-thirds pass ⅛-inch, and the weight (well

jarred down) is less than 120 lbs., the material is not the best.

CINDERS are sometimes used for block work; they vary greatly in quality, but if clean and of medium coarseness will give fair results. Cinder concrete never develops great strength, owing to the porous character and crushability of the cinders themselves. Cinder blocks may, however, be strong enough for many purposes, and suitable for work in which great strength is not required.

LIME.—It is well known that slaked lime is a valuable

addition to cement mortar, especially for use in air. In sand mixtures, 1 to 4 or 1 to 5, at least one-third of the cement may be replaced by slaked lime without loss of strength. The most convenient form of lime for use in block-making is the dry-slaked or hydrate lime, now a common article of commerce. This is, however, about as expensive as Portland cement, and there is no great saving in its use. Added to block concrete, in the proportion of ¼ to ½ the cement used, it will be found to make the blocks lighter in color, denser, and decidedly less permeable by water.

CEMENT.—Portland cement, to-day, is the only hydraulic

material to be seriously considered by the block-maker, and at present prices there is nothing gained by attempting the use of any of the cheaper substitutes. Natural and slag cements and hydraulic lime are useful for work which remains constantly wet, but greatly inferior in strength and durability when exposed to dry air. A further advantage of Portland cement is the promptness with which it hardens and develops its full strength; this quality alone is sufficient to put all other cements out of consideration for block work.

PROPORTIONS.

There are three important considerations which must be kept in view in adjusting the proportions of materials for block concrete—strength, permeability, and cost.

So far as strength goes, it may easily be shown that concretes very poor in cement, as 1 to 8 or 1 to 10, will have a crushing resistance far beyond any load that they may be called upon to sustain. Such concretes are, however, extremely porous, and absorb water like a sponge. It is necessary, also, that the blocks shall bear a certain amount of rough handling at the factory and while being carted to work and set up in the wall, and safety in this respect calls for a much greater degree of hardness than would be needed to bear the weight of the building. Again, strength and hardness, with a given proportion of cement, depend greatly on the character of the other materials used; blocks made of cement and sand, 1 to 3, will not be so strong or so impermeable to water as those made from a good mixed sand and gravel, 1 to 5. On the whole, it is doubtful whether blocks of satisfactory quality can be made, by hand mixing and tamping, under ordinary factory conditions, from a poorer mixture than 1 to 5. Even this proportion requires for good results the use of properly graded sand and gravel or screenings, a liberal amount of water, and thorough mixing and tamping. When suitable gravel is not obtainable, and coarse mixed sand only is used, the proportion should not be less than 1 to 4. Fine sand alone is a very bad material, and good blocks cannot be made from it except by the use of an amount of cement which would make the cost very high.

The mixtures above recommended, 1 to 4 and 1 to 5, will necessarily be somewhat porous, and may be decidedly so if

the gravel or screenings used is not properly graded. The water-resisting qualities may be greatly improved, without loss of strength, by replacing a part of the cement by hydrate lime. This is a light, extremely fine material, and a given weight of it goes much further than the same amount of cement in filling the pores of the concrete. It has also the effect of making the wet mixture more plastic and more easily compacted by ramming, and gives the finished blocks a lighter color.

The following mixtures, then, are to be recommended for concrete blocks. By "gravel" is meant a suitable mixture of sand and gravel, or stone screenings, containing grains of all sizes, from fine to ½-inch:

1 to 4 Mixtures, by Weight

Cement 150, gravel 600.
Cement 125, Hyd. lime 25, gravel 600.
Cement 100, Hyd. lime 50, gravel 600.

1 to 5 Mixtures, by Weight

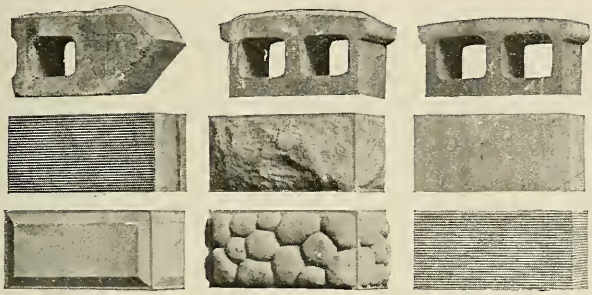
Cement 120, gravel 600.
Cement 100, Hyd. lime 20, gravel 600.

PROPORTION OF WATER.—This is a matter of the utmost consequence, and has more effect on the quality of the work than is generally supposed. Blocks made from too dry concrete will always remain soft and weak, no matter how thoroughly sprinkled afterwards. On the other hand, if blocks are to be removed from the machine as soon as made, too much water will cause them to stick to the plates and sag out of shape. It is perfectly possible, however, to give the concrete enough water for maximum density and first-class hardening properties, and still to remove the blocks at once from the mould. A good proportion of coarse material allows the mixture to be made wetter without sticking or sagging. Use of plenty of water vastly improves the strength, hardness and water-proof qualities of blocks, and makes them decidedly lighter in color. The rule should be:

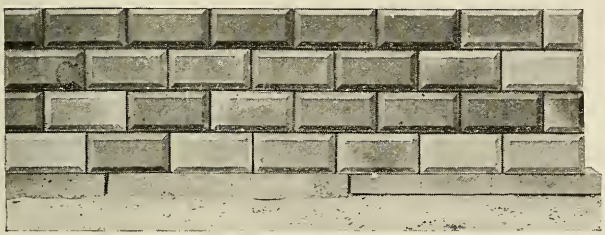
Use as much water as possible without causing the blocks to stick to the plates or to sag out of shape on removing from the machine.

The amount of water required to produce this result varies with the materials used, but is generally from 8 to 9 per

cent. of the weight of the dry mixture. A practiced block-maker can judge closely when the right amount of water has been added, by squeezing some of the mixture in the hand. Very slight variations in proportion of water make such a marked difference in the quality and color of the blocks that the water, when the proper quantity for the materials used has been determined, should always be accurately measured out for each batch. In this way much time is saved and uncertainty avoided.



BLOCKS WITH VARIOUS STYLES OF FACE.



WALL OF PANELED BLOCKS.

FACING.—Some block-makers put on a facing of richer and finer mixture, making the body of the block of poorer and coarser material. As will be explained later, the advantage of the practice is, in most cases, questionable, but facings may serve a good purpose in case a colored or specially waterproof surface is required. Facings are generally made of cement and sand or fine screenings, passing a $\frac{1}{8}$ inch sieve. To get the same hardness and strength as a 1 to 5 gravel mixture, at least as rich a facing as 1 to 3 will be found necessary. Probably 1 to 2 will be found better, and if one-third

the cement be replaced by hydrate lime the water-proof qualities and appearance of the blocks will be improved. A richer facing than 1 to 2 is liable to show greater shrinkage than the body of the block, and to adhere imperfectly or develop hair-cracks in consequence.

POURED WORK.—The above suggestions on the question of proportions of cement, sand and gravel for tamped blocks apply equally to concrete made very wet, poured into the

ROCK-FACED WALL AND ORNAMENTAL CORNICE.

mould, and allowed to harden a day or longer before removing. Castings in a sand mould are made by the use of very liquid concrete; sand and gravel settle out too rapidly from such thin mixtures, and rather fine limestone screenings are generally used.

MIXING.

To get the full benefit of the cement used it is necessary that all the materials shall be very thoroughly mixed together. The strength of the block as a whole will be only as great as

that of its weakest part, and it is the height of folly, after putting in a liberal measure of cement, to so slight the mixing as to get no better result than half as much cement, properly mixed, would have given. The poor, shoddy and crumbly blocks turned out by many small-scale makers owe their faults chiefly to careless mixing and use of too little water, rather than to too small proportion of cement.

The materials should be mixed, dry, until the cement is uniformly distributed and perfectly mingled with the sand and gravel or screenings; then the water is to be added and the mixing continued until all parts of the mass are equally moist and every particle is coated with the cement paste.

CONCRETE MIXERS.—Hand-mixing is always imperfect, laborious and slow, and it is impossible by this method to secure the thorough stirring and kneading action which a good mixing machine gives. If a machine taking 5 or 10 horse power requires five minutes to mix one-third of a yard of concrete, it is of course absurd to expect that two men will do the same work by hand in the same time. And the machine never gets tired or shirks if not constantly urged, as it is the nature of men to do. It is hard to see how the manufacture of concrete blocks can be successfully carried on without a concrete mixer. Even for a small business it will pay well in economy of labor and excellence of work to install such a machine, which may be driven by a small electric motor or gasoline engine. In work necessarily so exact as this, requiring perfectly uniform mixtures and use of a constant percentage of water, *batch mixers*, which take a measured quantity of material, mix it, and discharge it, at each operation, are the only satisfactory type, and continuous mixers are unsuitable. Those of the pug-mill type, consisting of an open trough with revolving paddles and bottom discharge, are positive and thorough in their action, and permit the whole operation to be watched and controlled. They should be provided with extensible arms of chilled iron, which can be lengthened as the ends become worn.

SYSTEMS OF CONCRETE CONSTRUCTION.

SOLID OR MONOLITHIC WALLS.—Foundations, walls and complete buildings of solid concrete have been erected in great numbers since the days of the Romans, and in modern times

the use of reinforced or armored concrete has adapted this type of construction to a great variety of uses. In this class of work, walls, cornices, and ornamental details of buildings are moulded in place, by the use of special forms held in position by various mechanical devices. This is necessarily somewhat expensive, and requires a high degree of skill on the part of the builder; it can be successfully done only by contractors who make a specialty of the process and are provided with all necessary appliances.

CONCRETE BLOCK SYSTEMS.—For smaller and less costly buildings, *separate blocks*, made at the factory and built up into the walls in the same manner as brick or blocks of stone, are simpler, less expensive and much more rapid in construction than monolithic work. They also avoid some of the faults to which solid concrete work, unless skillfully done, is subject, such as the formation of shrinkage cracks.

There are two systems of block making, differing in the consistency of the concrete used:

1.—Blocks tamped or pressed from semi-wet concrete, and removed at once from the mould.

2.—Blocks poured or tamped from wet concrete, and allowed to remain in the mould until hardened.

TAMPED BLOCKS FROM SEMI-WET MIXTURE.—These are practically always made on a block-machine, so arranged that as soon as a block is formed the cores and side-plates are removed and the block lifted from the machine. By far the larger part of the blocks on the market are made in this way. Usually these are of the *one-piece* type, in which a single block, provided with hollow cores, makes the whole thickness of the wall. Another plan is the *two-piece* system, in which the face and back of the wall are made up of different blocks, so lapping over each other as to give a bond and hold the wall together. Blocks of the two-piece type are generally formed in a hand or hydraulic press.

Various shapes and sizes of blocks are commonly made; the builders of the most popular machines have, however, adopted the standard length of 32 inches and height of 9 inches for the full-sized block, with thickness of 8, 10 and 12 inches. Lengths of 24, 16 and 8 inches are also obtained on the same machines by the use of parting plates and suitably divided face

plates; any intermediate lengths and any desired heights may be produced by simply adjustments or blocking off.

Blocks are commonly made plain, rock-faced, tool-faced, paneled, and of various ornamental patterns. New designs of face plates are constantly being added by the most progressive machine-makers. The following illustrations show some of the forms of blocks most commonly made:

BLOCK MACHINES.—There are many good machines on the market, most of which are of the same general type, and differ only in mechanical details. They may be divided into two classes: those with vertical and those with horizontal face. In the former the face plate stands vertically, and the block is simply lifted from the machine on its base plate as soon as tamped. In the other type the face plate forms the bottom of the mould; the cores are withdrawn horizontally, and by the motion of a lever the block with its face plate is tipped up into a vertical position for removal. In case it is desired to put a facing on the blocks, machines of the horizontal-face type are considered the more convenient, though a facing may easily be put on with the vertical-face machine by the use of a parting plate.

BLOCKS POURED FROM WET CONCRETE.—As already stated, concrete made too dry is practically worthless, and an excess of water is better than a deficiency. The above-described machine process, in which blocks are tamped from damp concrete and at once removed, gives blocks of admirable hardness and quality if the maximum of water is used. A method of making blocks from very wet concrete, by the use of a large number of separable moulds of sheet steel, into which the wet concrete mixture is poured and in which the blocks are left to harden for 24 hours or longer, has come into considerable use. By this method blocks of excellent hardening and resistance to water are certainly obtained. Whether the process is the equal of the ordinary machine method in respect of economy and beauty of product, must be left to the decision of those who have had actual experience with it.

The well-known cast-stone process consists in pouring liquid concrete mixture into a sand mould made from a pattern in a manner similar to that in which moulds for iron castings are produced. The sand absorbs the surplus water from the

liquid mixture, and the casting is left in the mould for 24 hours or longer until thoroughly set. This process necessitates the making of a new sand mould for every casting, and is necessarily much less rapid than the machine method. It is less extensively used for building blocks than for special ornamental architectural work, sills, lintels, columns, capitals, etc., and for purposes of this kind it turns out products of the highest quality and beauty.

TAMPING OF CONCRETE BLOCKS.—This is generally done by means of hand-rammers. Pneumatic tampers, operated by an air-compressor, are in use at a few plants, apparently with considerable saving in time and labor and improvement in quality of work. Moulding concrete by *pressure*, either mechanical or hydraulic, is not successful unless the pressure is applied to the face of a comparatively thin layer. If compression of thick layers, especially of small width, is attempted, the materials arch and are not compacted at any considerable depth from the surface. Moulding blocks by pressure is therefore practiced only in the two-piece system, in which the load is applied to the surface of pieces of no great thickness. Hand tamping must be conscientious and thorough, or poor work will result. It is important that the mould should be filled a little at a time, tamping after each addition; at least four fillings and tampings should be given to each block. If the mixture is wet enough no noticeable layers will be formed by this process.

HARDENING AND STORAGE.—Triple decked cars to receive the blocks from the machines will be found a great saving of labor, and are essential in factories of considerable size. Blocks will generally require to be left on the plates for at least 24 hours, and must then be kept under roof, in a well-warmed room, with frequent sprinkling, for not less than five days more. They may then be piled up out of doors, and in dry weather should be wetted daily with a hose. Alternate wetting and drying is especially favorable for the hardening of cement, and concrete so treated gains much greater strength than if kept continuously in water or dry air.

Blocks should not be used in building until at least four weeks from the time they are made. During this period of seasoning, blocks will be found to shrink at least 1-16 inch in

length, and if built up in a wall when freshly made, shrinkage cracks in the joints or across the blocks will surely appear.

EFFLORESCENCE, or the appearance of a white coating on the surfaces, sometimes takes place when blocks are repeatedly saturated with water and then dried out; blocks laid on the ground are more liable to show this defect. It results from diffusion of soluble sulphates of lime and alkalies to the surface. It tends to disappear in time, and rarely is sufficient in amount to cause any complaint.

PROPERTIES OF CONCRETE BLOCKS.

Strength.

In the use of concrete blocks for the walls of buildings, the stress to which they are subjected is almost entirely one of *compression*. In compressive strength well-made concrete does not differ greatly from ordinary building stone. It is difficult to find reliable records of tests of sand and gravel concrete, 1 to 4 and 1 to 5, such as is used in making blocks; the following figures show strength of concrete of approximately this richness, also the average of several samples each of well-known building stones, as stated by the authorities named:

Limestone, Bedford, Ind. (Ind. Geo. Survey)	7792 lbs.
" Marblehead, Ohio, (Q. A. Gillmore)	7393 "
Sandstone, N. Amherst, Ohio, "	5831 "
Gravel Concrete, 1 :1.6:2.8, at 1 yr. (Candlot)	5500 "
" " 1 :1.6:3.7, " " " "	5050 "
Stone Concrete, 1 :2:4 at 1 yr. (Boston El. R. R.)	3904 "

Actual tests of compression strength of hollow concrete blocks are difficult to make, because it is almost impossible to apply the load uniformly over the whole surface, and also because a block 16 inches long and 8 inches wide will bear a load of 150,000 to 200,000 lbs., or more than the capacity of any but the largest testing machines. Three one-quarter blocks, 8 inches long, 8 inches wide and 9 inches high, with hollow space equal to one-third of the surface, tested at the Case School of Science, showed strengths of 1,805, 2,000 and 1,530 lbs. per square inch, respectively, when 10 weeks old.

Two blocks 6x8x9 inches, 22 months old, showed crushing strength of 2,530 and 2,610 lbs. per sq. inch.

These blocks were made of cement 1¼, lime ½, sand and gravel 6, and were tamped from damp mixture.

It is probably safe to assume that the minimum crushing strength of well-made blocks, 1 to 5, is 1,000 lbs. per square inch at one month and 2,000 lbs. at 1 year.

Now a block 12 inches wide and 24 inches long has a total surface of 288 sq. inches, or, deducting 1-3 for openings, a net area of 192 inches. Such a block, 9 inches high, weighs 130 lbs. Assuming a strength of 1000 lbs. and a factor of safety of 5, the safe load would be 200 lbs. per sq. inch, or 200×192=38,400 lbs. for the whole surface of the block. Dividing this by the weight of the block, 130 lbs., we find that 295 such blocks could be placed one upon another, making a total height of wall of 222 ft., and still the pressure on the lowest block would be less than one-fifth of what it would actually bear.

This shows how greatly the strength of concrete blocks exceeds any demands that are ever made upon it in ordinary building construction.

The safe load above assumed, 200 lbs., seems low enough to guard against any possible failure. In Taylor and Thompson's work on concrete, a safe load of 450 lbs. for concrete 1 to 2 to 4 is recommended; this allows a factor of safety of 5½. On the other hand, the Building Code of the City of Cleveland permits concrete to be loaded only to 150 lbs. per sq. inch, and limits the height of walls of 12-inch blocks to 44 ft. The pressure of such a wall would be only 40 lbs. per square inch; adding the weight of 2 floors at 25 lbs. per sq. ft. each, and roof with snow and wind pressure, 40 lbs. per sq. ft., we find that with a span of 25 ft. the total weight on the lowest blocks would be only 52 lbs. per sq. inch, or about one-twentieth of their minimum compression strength.

Blocks with openings equal to only one-third the surface, as required in many city regulations, are heavy to handle, especially for walls 12 inches and more in thickness, and, as the above figures show, are enormously stronger than there is any need of. Blocks with openings of 50 per cent. would be far more acceptable to the building trade, and if used in walls not over 44 ft. high, with floors and roof calculated as above for 25 feet span, would be loaded only to 56 lbs. per square inch of actual surface. This would give a factor of safety of 18 assuming a minimum of compression strength of 1,000 lbs.

There is no doubt that blocks with one-third opening are inconveniently and unnecessarily heavy. Such a block, 32 inches long, 12 inches wide, and 9 inches high, has walls about 3½ inches thick, and weighs 180 lbs. A block with 50 per cent. open space would have walls and partitions 2 inches in thickness, and would weigh about 130 lbs. With proper care in manufacture, especially by using as much water as possible, blocks with this thickness of walls may be made thoroughly strong, sound and durable. It is certainly better for strength and water-resisting qualities to make thin-walled blocks of rich mixture, rather than heavy blocks of poor and porous material.

WATER-PROOF QUALITIES.

The chief fault of concrete building blocks, as ordinarily made, is their tendency to absorb water. In this respect they are generally no worse than sandstone or common brick; it is well known that stone or brick walls are too permeable to allow plastering directly on the inside surface, and must be furred and lathed before plastering, to avoid dampness. This practice is generally followed with concrete blocks, but their use and popularity would be greatly increased if they were made sufficiently water-proof to allow plastering directly on the inside surface.

For this purpose it is not necessary that blocks should be perfectly water-proof, but only that the absorption of water shall be *slow*, so that it may penetrate only part way through the wall during a long-continued rain. Walls made entirely water-tight, are, in fact, objectionable owing to their tendency to "sweat" from condensation of moisture on the inside surface. For health and comfort, walls must be slightly porous, so that any moisture formed on the inside may be gradually absorbed and carried away.

Excessive water-absorption may be avoided in the following ways:

1.—USE OF PROPERLY GRADED MATERIALS.—It has been shown by Feret and others that porosity and permeability are two different things; porosity is the total proportion of voids or open spaces in the mass, while permeability is the rate at which water, under a given pressure, will pass through it. Permeability depends on the *size* of the openings as well as on their total amount. In two masses of the same porosity or

percentage of voids, one consisting of coarse and the other of fine particles, the permeability will be greater in case of the coarse material. The least permeability, and also the least porosity, are, however, obtained by use of a suitable mixture of coarse and fine particles. Properly graded gravel or screenings, containing plenty of coarse fragments and also enough fine material to fill up the pores, will be found to give a much less permeable concrete than fine or coarse sand used alone.

2.—USE OF RICH MIXTURES.—All concretes are somewhat permeable by water under sufficient pressure. Mixtures rich in cement are of course much less permeable than poorer mixtures. If the amount of cement used is more than sufficient to fill the voids in the sand and gravel, a very dense concrete is obtained, into which the penetration of water is extremely slow. The permeability also decreases considerably with age, owing to the gradual crystallization of the cement in the pores, so that concrete which is at first quite absorbent may become practically impermeable after exposure to weather for a few weeks or months. There appears to be a very decided increase in permeability when the cement is reduced below the amount necessary to fill the voids. For example, a good mixed sand and gravel weighing 123 lbs. per cubic foot, and therefore containing 25 per cent. voids, will give a fairly impermeable concrete in mixtures up to 1 to 4, but with less cement will be found quite absorbent. A gravel with only 20 per cent. voids would give about equally good results with a 1 to 5 mixture; such gravel is, however, rarely met with in practice. On the other hand, the best sand, mixed fine and coarse, seldom contains less than 33 per cent. voids, and concrete made from such material will prove permeable if poorer than 1 to 3.

Filling the voids with cement is a rather expensive method of securing water-proof qualities, and gives stronger concretes than are needed. The same may be accomplished more cheaply by replacing part of the cement by slaked lime, which is an extremely fine-grained material, and therefore very effective in closing pores. Hydrate lime is the most convenient material to use, but nearly as costly as Portland cement at present prices. A 1 to 4 mixture in which one-third the cement is replaced by hydrate lime will be found equal to a 1 to 3 mixture without the lime. A 1 to 4 concrete made from cement

1, hydrate lime ½, sand and gravel 6 (by weight), will be found fairly water-tight, and much superior in this respect to one of the same richness consisting of cement 1½, sand and gravel 6.

The cost of lime may be greatly reduced by using ordinary lump lime slaked to a paste. The lime must, however, be very thoroughly hydrated, so that no unslaked fragments may remain to make trouble by subsequent expansion. Lime paste is also very difficult to mix, and can be used successfully only in a concrete mixer of the pug-mill type. Ordinary stiff lime paste contains about 50 per cent. water; twice as much of it by weight, should therefore be used as of dry hydrate lime.

3.—USE OF A FACING.—Penetration of water may be effectively prevented by giving the blocks a facing of richer mixture than the body. For the sake of smooth appearance, facings are generally made of cement and fine sand, and it is often noticed that these do not harden well. It should be remembered that a 1 to 3 sand mixture is no stronger and little if any better in water absorption than a 1 to 5 mixture of well graded sand and gravel. To secure good hardness and resistance to moisture a facing as rich as 1 to 2 should be used.

4.—USE OF AN IMPERVIOUS PARTITION.—When blocks are made on a horizontal-face machine, it is a simple matter, after the face is tamped and cores pushed into place, to throw into each opening a small amount of rich and rather wet mortar, spread this fairly evenly, and then go on tamping in the ordinary mixture until the mould is filled. A dense layer across each of the cross-walls is thus obtained, which effectually prevents moisture from passing beyond it. A method of accomplishing the same result with vertical-face machines, by inserting tapered wooden blocks in the middle of the cross-walls, withdrawing these blocks after tamping and filling the spaces with rich mortar, has lately been patented by Purdy and Henderson, of New York. In the two-piece system the penetration of moisture through the wall is prevented by leaving an empty space between the web of the block and the inside face, or by filling this space with rich mortar.

5.—USE OF WATER-PROOF COMPOUNDS.—There are compounds on the market, of a fatty or waxy nature, which, when

mixed with cement to the amount of only one or two per cent of its weight, increase its water-resisting qualities in a remarkable degree. By thoroughly mixing 1 to 2 lbs. of suitable compound with each sack of cement used, blocks which are practically water-proof may be made, at very small additional cost, from 1 to 4 or 1 to 5 mixtures. In purchasing water-proof compound, however, care should be taken to select such as has been proved to be *permanent* in its effect, as some of the materials used for this purpose lose their effect after a few days' exposure to weather, and are entirely worthless.

6.—APPLICATIONS TO SURFACE AFTER ERECTING.—Various washes, to make concrete and stone impervious to water, have been used with some success. Among these the best known is the Sylvester wash of alum and soap solution. It is stated this requires frequent renewal, and it is hardly likely to prove of any value in the concrete block industry. The writer's experience has been that the most effective remedy, in case a concrete building proves damp, is to give the outside walls a *very thin* wash of cement suspended in water. One or two coats will be found sufficient. If too thick a coating is formed it will show hair cracks. The effect of the cement wash is to make the walls appear lighter in color, and if the coating is thin the appearance is in no way injured.

GENERAL HINTS ON WATER-PROOF QUALITIES.—To obtain good water-resisting properties, the first precaution is to make the concrete *sufficiently wet*. Dry-tamped blocks, even from rich mixture, will always be porous and absorbent, while the same mixture in plastic condition will give blocks which are dense, strong, and water-tight. The difference in this respect is shown by the following tests of small concrete blocks, made by the writer. The concrete used was made of 1 part cement and 5 parts mixed fine and coarse sand by weight.

No. 1—With 8 per cent. water, rather dryer than ordinary block concrete, tamped in mould.

No. 2.—With 10 per cent. water, tamped in mould, too wet to remove mould at once.

No. 3.—With 25 per cent. water, poured into a mould resting on a flat surface of dry sand; after 1 hour the surface was troweled smooth; mould not removed until set.

These blocks were allowed to harden a week in moist air,

then dried. The weights, voids, and water absorption were as follows:

	1	2	3
	Damp-tamped.	*Wet-tamped.*	*Poured.*
Weight per cubic foot, lbs	122.2	123.9	110.0
Voids, calculated, per cent. of volume	25.9	24.9	33.3
Water required to fill voids, per cent of wt.	9.8	9.4	12.5
Water absorbed after 2 hours, per cent. of wt.	8.8	6.4	10.5

The rate at which these blocks absorb water was then determined by drying them thoroughly, then placing them in a tray containing water ¼ inch in depth, and weighing them at intervals.

Water absorbed per cent. by weight.	1 *Damp-tamped.*	2 *Wet-tamped.*	3 *Poured.*
½ hour	2.0	0.9	1.8
1 "	3.2	1.1	2.5
2 hours	4.1	1.6	3.2
4 "	5.2	2.0	3.8
24 "	6.1	3.4	7.0
48 "	6.4	4.3	7.5

These figures show that concrete which is sufficiently wet to be thoroughly plastic absorbs water much more slowly than dryer concrete, and prove the importance of using as much water as possible in the damp-tamping process.

COST.

The success of the hollow concrete block industry depends to a great extent on cheapness of product, since it is necessary, in order to build up a large business, to compete in price with common brick and rubble stone. At equal cost, well-made blocks are certain to be preferred, owing to their superiority in strength, convenience, accurate dimensions, and appearance. For the outside walls of handsome buildings, blocks come into competition with pressed brick and dressed stone, which are of course, far more costly. Concrete blocks can be sold and laid up at a good profit at 25 cents per cubic foot of wall. Common red brick costs generally about 12 dollars per thousand, laid. At 24 to the cubic foot, a thousand

brick are equal to 41.7 cu. ft. of wall; or, at $12, 29c. per cu. ft. Brick walls with pressed brick facing cost from 40c. to 50c. per cubic foot, and dressed stone from $1 to $1.50 per foot.

The factory cost of concrete blocks varies according to the cost of materials. Let us assume cement to be $1.50 per barrel of 380 lbs., and sand and gravel 25c. per ton. With a 1 to 4 mixture, 1 barrel cement will make 1,900 lbs. of solid concrete, or at 130 lbs. per cu. ft., 14.6 cubic feet. The cost of materials will then be

Cement, 380 lbs.	$1.50
Sand and gravel, 1,520 lbs.	0.19
Total	$1.69

or 11.5c. per cu. ft. solid concrete. Now, blocks 9 inches high and 32 inches long make 2 square feet of face of wall, each. Blocks of this height and length, 8 inches thick, make 1 1-3 cubic feet of wall; and blocks 12 inches thick make 2 cubic feet of wall. From these figures we may calculate the cost of materials for these blocks, with cores or openings equal to 1-3 or ½ the total volume, as follows:

Per cu. ft. of block, 1-3 opening	7.7 cts.
Per cu. ft. of block, ½ opening	5.8 "
Block 8x9x32 inches, 1-3 opening	10.3 "
Block 8x9x32 inches, ½ opening	7.7 "
Block 12x9x32 inches, 1-3 opening	15.4 "
Block 12x9x32 inches, ½ opening	11.6 "

If one-third of the cement is replaced by hydrate lime the quality of the blocks will be improved, and the cost of material reduced about 10 per cent.

The cost of labor required in manufacturing, handling and delivering blocks will vary with the locality and the size and equipment of factory. With hand-mixing, 3 men at average of $1.75 each will easily make 75 8-inch or 50 12-inch blocks, with 1-3 openings, per day. The labor cost for these sizes of blocks will therefore be 7c. and 10½c. respectively. At a factory equipped with power concrete mixer and cars for transporting blocks, in which a number of machines are kept busy, the labor cost will be considerably less. An extensive industry located in a large city is, however, subject to many expenses which are avoided in a small country plant, such as high wages,, management, office rent, advertising, etc., so that

the total cost of production is likely to be about the same in both cases. A fair estimate of total factory cost is as follows:

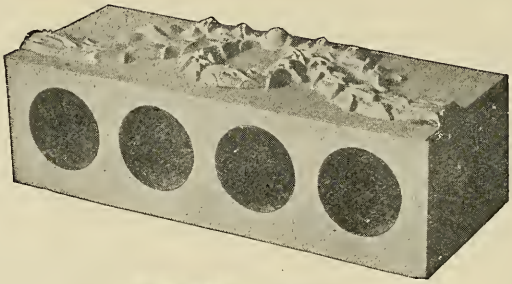
	Material.	*Labor.*	*Total.*
8x32 inch, 1-3 space	10.3	7	17.3 cts.
8x32 inch, ½ "	7.7	6	13.7 "
12x32 inch, 1-3 "	15.4	10.5	25.9 "
12x32 inch, ½ "	11.6	9	20.6 "

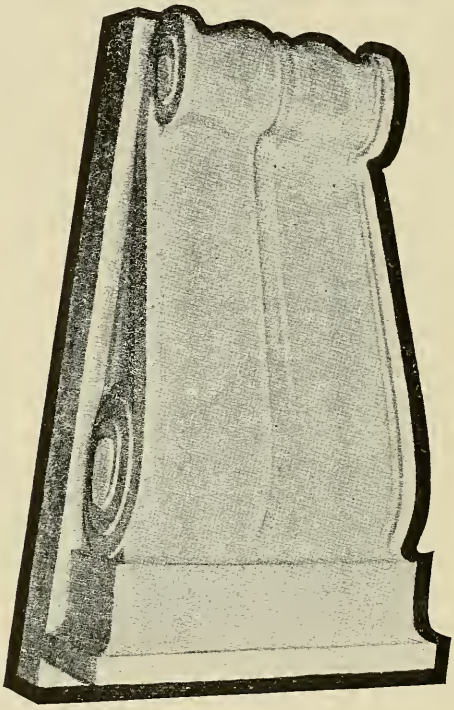
With fair allowance for outside expenses and profit, 8-inch blocks may be sold at 30c. and 12-inch at 40c. each. For laying 12-inch blocks in the wall, contractors generally figure about 10c. each. Adding 5c. for teaming, the blocks will cost 55c. each, erected, or 27½c. per cubic foot of wall. This is less than the cost of common brick, and the above figures show that this price could be shaded somewhat, if necessary, to meet competition.

APPEARANCE AND USE.

Since concrete blocks are, as has been shown, more convenient, more efficient, and cheaper than any other building material, it would naturally be expected that they would quickly take the place of wood, brick and stone and be generally adopted for all ordinary construction. The growth of the block industry has, indeed, been rapid, but it plays as yet but a small part in the building operations of the country. It is evident on all sides that concrete blocks meet with opposition and suspicion on the part of architects and builders, and in consequence are much less generally adopted than their merits appear to warrant. It is neither just nor expedient to attribute this opposition to prejudice against a new material. Rather should we try to find and remove the grounds on which such opposition is based. My observation leads me to believe that architects and engineers have no prejudice against concrete, but on the contrary, welcome it as a building material by means of which they can obtain results never before within their reach. And they are also keenly watching the block industry, and are ready to adopt block construction as soon as they are offered a product which meets their ideas as to utility and beauty.

Fortunately, no material is so elastic in its capabilities as concrete, and no other can with so little effort be adapted to produce any effect desired. It is hardly to be expected that





ORNAMENTAL ARCHITECTURAL WORK
MADE BY THE CAST STONE PROCESS

the block of the present day will be the block of the future; the type which is most economical, practical and beautiful will gradually come to the front, and that which is costly, clumsy and ugly will become a thing of the past. To make a success of the business we must keep our eyes open, watch what others are doing in the way of invention and improvement, and study the wants of customers. And we must not hesitate

to throw our old block machines into the scrap heap when we are sure we have found a better apparatus and process.

The objections which architects and builders make to blocks now on the market are chiefly the following:

Poor workmanship,
Fixed dimensions,
Too great weight,
Unpleasing appearance.

As to workmanship, shoddy, weak and crumbling blocks are far too often met with. Good concrete should be hard and dense, and should give out a musical tone when struck with a hammer. If your blocks sound dead when struck, and break easily with an earthy fracture, you are either using too poor a mixture or working too dry, probably the latter. It does not pay, for the sake of low factory cost to turn out work of this kind. If there is any money to be made in the block business it will be made by furnishing a good article at a living price, and in no other way. Will any one argue that it pays to make rotten blocks at a factory cost of two cents less than good ones? My belief is that the tendency of the future will be toward the use of wetter concrete, and the adoption of a process which makes this possible.

As to fixed dimensions of blocks, the standard length of 32 inches, divided into halves, thirds and quarters, is very convenient, and is generally conformed to by architects, for simple work, without much objection. To be fully successful, however, and to overcome all prejudice, the block-maker must be ready to furnish any size or shape that may be called for to suit architects' designs. It would be very pleasant if we could confine ourselves to the standard size and let customers "take it or leave it." But such an attitude bars the way to any wide use of blocks in varied and attractive buildings, and cannot be maintained without loss of trade. Architects want also courses of greater or less height than the 9 inch standard, and all manner of cornices, copings, columns and capitals. This may frighten the timid and conservative block-maker, but it is in that direction that success lies, and the production of these special shapes requires only ingenuity, courage and mechanical skill. Until we can say to the architect "Design whatever you like, we'll make it for you," he will shy at us

and our product. He will, of course, readily appreciate that special shapes cost more than standard, and if he knows he can get just what he wants he will be more likely to accept, so far as he can, what can be conveniently and cheaply furnished.

Preference should be given, therefore, to the machine which permits the greatest variety of sizes and shapes to be easily made. And the greatest business success is likely to come to the manufacturer who shows the least inclination to get into a rut, and is most ready to adapt his product to the wants of his patrons.

The objection to the weight of the one-piece block comes chiefly from masons and contractors. Hoisting 12x32 inch blocks weighing 180 lbs. to the upper floors of a building, and handling them onto the wall, is a considerable task, and it is largely on this account that the half-block of the two-piece system, 24 inches long, weighing only 64 lbs., is received with so much favor. It must be remembered, however, that the two-piece blocks make a wall with over 50 per cent. opening, and a one-piece block of the same thickness of walls—2 inches—would also be light to handle and doubtless very popular. My belief is that the one-piece block of the future will be 24 inches long and with a thickness of walls of not over 2 inches. Such a block, 12 inches wide and 9 inches high, will weigh only 97 lbs., and if well and honestly made will bear rough handling and any possible load.

Finally it is to the *appearance* of concrete blocks, as ordinarily made and used, that architects and other persons of taste and judgment make the greatest objection. Anything that savors of imitation, that pretends to be what it is not, will always be hated and condemned by all who know the difference between the good and the bad. The common rock-faced block is an imitation of the cheapest form of quarry stone, and a poor imitation at that, for no two natural stone blocks are alike in surface; while even if you have half a dozen rock-face plates of the same size of block, and strive to shuffle up the product of these plates in the yard and on the work, you will never see a building in which, here and there, blocks from the same plate are not found one above or beside the other. And it is surprising how unerringly the eye will pick

out the spots where this occurs, and what a feeling of "something lacking" is awakened. It is bad art, and quite indefensible. The "rock-faced galvanized iron" of our country storefronts is a no more glaring fraud. The rock-faced block must go.

Now let us inquire what constitutes imitation, and how concrete may be made to stand on its merits and look like what it really is. In the first place, concrete must always look like stone, because it *is* stone. An artificial stone, consisting of grains of sand and gravel or limestone crystals bound together by a little Portland cement, cannot help looking like natural sandstone or limestone made up of the same materials bound together by carbonate of lime or soluble silicates slowly deposited in its pores. We need never be afraid that concrete will be condemned for its stony look, since that is its nature. All we need to avoid is giving the work an appearance which is unnatural to concrete, such as the rock-face. Smooth, ribbed and paneled surfaces, also good ornamental patterns for friezes or cornices, are entirely legitimate, and equally characteristic of stone, metal, terra cotta or concrete. Forms of beauty may properly be reproduced in any material; the only thing to be avoided is pretense—the attempt to deceive the observer into the belief that the material he sees is something different from what it really is.

The surface which best pleases the eye of artist and architect is a rough and varied one, rather than the smooth, dead look which rich cement mi xtures have. The film of cement which coats the face of the work is certainly monotonous and unattractive. This can be cheaply removed by washing with very weak acid, and very beautiful effects are thus obtained, especially with crushed stone or gravels containing pebbles of various colors.

CITY SPECIFICATIONS FOR CONCRETE BLOCKS.

In order to guard against the use of blocks of poor quality and to insure safe construction of block buildings, a number of cities have adopted specifications for the acceptance and use of building blocks of concrete. The building regulations of New York City* in regard to all materials used as substitutes for brick or stone are extremely severe, requir-

*Cement Age, Sept., '05, p. 274.

ing tests to be made on blocks the size and shape of an ordinary brick, which must show an average modulus of rupture of 450 lbs. in transverse test, average compression strength of 3,000 lbs., water absorption not over 15 per cent., loss of not more than 33 per cent. strength after freezing and thawing 20 times, and no disintegration after heating 1 hour to 1,700 degrees F. and plunging into cold water.

The City of Philadelphia* for a time followed these requirements, but has lately modified them, and provides that tests of hollow concrete blocks shall be made on full-sized specimens. The most important requirements are:

Blocks to be made of Portland cement with not more than 5 parts sand and gravel or crushed rock; hollow space to be not over 33 per cent. (20 and 25 per cent. in lower parts of high walls); maximum load 111 lbs. per square inch of wall; crushing strength 1,000 lbs. per square inch of total surface of block including openings; absorption, freezing and fire tests as in New York requirements.

According to the Cement Age, concrete blocks in the Philadelphia market have shown compression strength of 1,200 to 1,600 lbs., absorption of about 5 per cent., little loss of strength on freezing, and have passed the fire test well.

The City of Newark, N. J. requires that blocks shall be not poorer than 1 to 4; they must be no more than 36 inches long and 10 inches high, and not less than 8 nor more than 16 inches wide; the hollow spaces must not exceed one-third; they must not be used until 30 days old, and must show a crushing strength of 1,500 lbs. per square inch.

These various city requirements seem generally reasonable and certainly abundantly severe. It is difficult to see, however, why the hollow spaces should be limited to one-third or less when strength is fully provided for by a compression requirement of 1,000 lbs. on the whole area of the block. If blocks with thinner walls will show this strength, there appears to be no ground for prohibiting them.

(Note: The cuts used in this paper were kindly loaned by The Progress Publishing Co., Ideal Concrete Machinery Co., Miracle Pressed Stone Co., and Stevens Cast Stone Co.)

*Cement Age, Sept., '05, p. 278.

DISCUSSION.

Mr. F. H. Gill: I would like to ask Mr. Newberry the size of the largest gravel which he uses in his 1 to 5 mixture.

Mr. Newberry: I would say that the block business with which our company is connected passes all the gravel through a one-inch screen and uses everything that passes that mesh. Unfortunately, the material that we have available does not contain a large proportion of gravel; at least not as much as we would like. And we do not get a very large proportion of particles that are larger than pea size. In my judgment, at least one-third of the material ought to be just a little larger than one-quarter inch, and I think our material is quite a bit below that. You can certainly use material up to an inch in size without any harm whatever.

Mr. M. S. Daniels: I would like to ask the speaker, when he speaks of gravel passed through a one-inch ring, whether he would also class as passing through a one-inch ring material from a stone crusher. Would you take all the material down to the dust which comes through a one-inch ring?

Mr. Newberry: I certainly would, as I do not think there would be any trouble in using material up to one inch. If it be a soft limestone, it is possible that you might get too much fine material. With a soft crushed limestone having a large amount of fine stone, the addition of hydrated or slaked lime is not a benefit at all.

Mr. M. S. Daniels: The material I speak of is from granite bowlders, crushed through an ordinary stone crusher, and bringing with it quite a considerable quantity of fine dust and sand and gravel to a one-sich size. Its strength is very great, but the inadvisability of using dust that clings to the stone that we have heard of this morning prompts my question.

Mr. Newberry: I did not hear the reference to that kind of dust, and the addition of any fine material always helps to fill up the voids and increases the density. Of course, larger aggregates must be used in proportion, and when you get everything

in a sufficient quantity present, then you will get good success. I would consider dust a benefit.

Mr. J. Robert Gill: How should clay be properly mixed in with the aggregate?

Mr. Newberry: If the clay comes with the gravel and sticks to it it would be a disadvantage if the mixing was not thorough enough to overcome that. I would not recommend that as a practical method at all, because it would not lead to good results. We use in the laboratory a proportion of one of cement to one of clay, and it has been our experience that sands which contain a small amount of clay will give a much greater strength to the product than washed sand. I think there was a paper read at the last years' meeting on that subject. There are a good many figures on record showing that washing of sand is a disadvantage.

Mr. J. Robert Gill: How can it be added in actual operation, so as to get the benefit and not the objections?

Mr. Newberry: I know it would be very difficult to overcome the bad results, but there are other fine materials, such as hydrated lime or the dust of limestone screenings, which fill the same purposes.

Mr. E. E. Truesdell: I understood Mr. Newberry to say that where common bank sand is used, sand and gravel with hydrated lime is beneficial. Now, how much of it is so, in proportion to a barrel of cement, taking a mixture of 1 to 5?

Mr. Newberry: For practical purposes, replacing one-third to one-fourth by lime. I found by laboratory tests that the addition of clay, equal parts, one of cement, one of clay, and 4, 5 or 6 of sand were in all cases very much stronger than one of cement, and the same amount of sand, without the clay; and, as a matter of fact, one of cement and one of clay, and 5 or 6 of sand, was pretty nearly as strong as two of cement, and 5 or 6 of sand. I would not recommend anybody to put clay into his blocks, but it is merely interesting, scientifically, that any fine material, no matter what it is, clay or finely divided silica, or any fine limestone, anything that will aid to fill the voids, will add to the density and strength of the blocks.

Mr. O. U. Miracle: Just a remark, in order to bring out that point and to emphasize the position we have always taken in the matter of clay in use for concrete blocks. We have always

contended that it was very unsafe, because we people, scattered around in the country, do not have laboratory facilities for making these tests. I still think that it is very unsafe to make such a recommendation.

Mr. H. J. Jaxon. What is the longexity of clay? Would it make the concrete last for a longer term of years?

Mr. Newberry: All the tests I have ever seen on record show good results at long periods, equally as good with sand containing a moderate percentage of clay, and no sign of falling off, nor do I see any reason why there should be any falling off.

Mr. Newberry: I am asked what kind of clay I mean. I just mean clay. The laboratory tests in our experience have not gone beyond that. Clay is a plastic material, and I guess they are pretty much alike. We did make some experiments with clay and sand, but, inasmuch as it did not cheapen the process, there was nothing special to recommend about it in the manufacture of concrete blocks. The main difficulty may be that the clay adheres to the sand and, therefore, prevents a close adhesion in mixing with the cement; but if they are mixed with a mixer this can readily be overcome.

Mr. E. T. Cairns: I would like to ask you if the cement was ground as fine as hydraulic lime, whether we could not obtain better results?

Mr. Newberry: I did not speak of hydraulic lime, but hydrated lime. Hydraulic lime is one which will harden under water. Hydrated lime is one which occurs in the market as a light, soft powder. I do not believe that it would be any better if the cement were ground to the same fineness; but I do not think it would be impossible to grind cement to that fineness, although if it were, it would be correspondingly expensive. In lime that is suspended in water in the form of lime dust, the particles are almost indefinitely small and pulverized to a degree which cannot be accomplished in cement.

Mr. Cairns: I mean hydrated lime made by the process used in Toledo. A throughly hydrated lime will give us a fineness of about 80 per cent with a 200 sieve. It is quite possible to grind cement as fine as that. I believe there is one kind of cement that does that. The question I want to bring out is whether the additional hydrated lime has been a beneficial feature in the block construction, and if these same cements were ground

to the degree of fineness of hydrated lime as supplied on the market, whether it would not be a better material in the long run.

Mr. Newberry: I do not think it would be practical to grind cement to that fineness. As soon as it is mixed into a paste with water it would make a very difficult material to handle. Theoretically, if cement could be made just as fine as hydrated lime, it would be just as good, but, practically, I do not think you could approach it.

Mr. Stevens: Did you find any difference in the clay with the wet or dry process?

Mr. Newberry: These were simply laboratory tests, and, as I say, the results were the same, whether it was added in dry powder or added as plastic clay in the mass.

Mr. Miller: Mr. Newberry spoke of the percentage of open space in the blocks, and said they could run up as high as 50 per cent. I would like to have his opinion as to what minimum thickness of wall shall be provided in a block. There must be some minimum thickness beyond which it is not safe to go.

Mr. Newberry: I do not quite see where the question of safety would enter, because, as it is made thinner, it is also made lighter and has less load to carry. I have seen most excellent blocks right here in this exhibit, which had partitions in them thoroughly hard and strong, not over one and one-half inches in thickness. I do not know how we could come to any conclusion about that, but I believe fully that two inches for a block twelve inches wide is abundantly strong.

Mr. E. S. Hotchkiss: What is the value of cinders? There are seven firms who are making concrete blocks and walls with cinders as a base for the sake of economy.

Mr. Newberry: Cinders are a very poor material, as far as strength is concerned; they are easily crushed, have many pores, which are never fully filled. But I will not say anything against it; it might be well adapted to some uses. Of course, we all have to work with the material we have at hand, and if our mixed sand and gravel weighs less than 125 pounds our material is not the best. I have not a very good opinion of cinder as material for concrete. I think it is useful for some purposes where great strength is not required.

Mr. H. J. Jaxon: I would like to ask Mr. Newberry

whether he has ever tested the cinder concrete with special reference to roughing plates, for instance.

Mr. Newberry: I have never tested it for that purpose, and have no figures of any kind, but I should think that it would be as good, as far as waterproofing qualities were concerned, as concrete made from any other material.

Mr. C. J. Farrar: Nearly all of the blocks that I have made have been of Allegheny River sand and Portland cement, mixed on a basis of 1 to 4, which, for ordinary buildings, I find a very satisfactory mixture. For finishing those blocks I have used a mixture of 1 to 3 crushed rock, sand and cement. For foundation work I have used a mixture of 3 of sand and 5 clean river gravel of the size that would about pass through a 1-inch screen.

Mr. Pierson: How would you classify that finishing sand? Is it fine?

Mr. Farrar: It is very fine.

Mr. Boynton: I would like to ask the gentleman that used the Allegheny sand if he has found any trouble with it; whether it is lifeless. I have heard people criticise the sands of the Allegheny River and West Virginia streams as sometimes being lifeless, unfit for mortars, and the theory was that they were contaminated with a sediment from the oil wells that ran into the streams.

Mr. Farrar: This sand was procured from the Allegheny at a point just above the city of Pittsburg. It is quite a long distance from the oil regions and there is no effect of the oil in the sand. It is very clean and very sharp and I think is the best sand that I ever saw for making cement blocks. They seem to be strong.

Mr. Driscoll: Underneath a limestone quarry, where the limestone was quarried out about 30 feet, we found a layer of sandstone It is hard sandstone of a very fine grain. To test its qualities we blasted it, made crushed sand, which we had milled for a filler, and with fine sand mixed with coarse sand we have had the best results of any material we have ever used. We cannot, however, get it in sufficient quantities to use generally. We made about a thousand caps and sills for a large paper mill in our town, and the nearest that I ever came to making a good quality of sandstone was by the use of a coarse sand and that fine pulverized sandstone.

I have read in German authorities that Nature has provided crushed sand with a bonding quality in itself; which is not destroyed by crushing. Is that the fact? I have seen recommendations from German authorities that you pulverize sand, add an equal quantity of Portland cement and you will get nearly the same result from your cement and double its sand-carrying power.

President Humphrey: There is one thing that we all ought to realize, and that is that concrete is a plastic material. Nature provides the stone, which you quarry and crush, mix it with sand and a certain amount of cement, a material which has the property of hardening and crystallizing when you add water. That material is plastic up to the point where it begins to set. The strength of the mixture when set depends, of course, on the strength of the material that you are sticking together, the aggregate.

The cement, which is the binder, cannot impart strength to the material itself. If the material be weak and soft like a soft sandstone or a cinder, no amount of cement will make that strong, but if you are using a hard limestone or a trap rock, then the resulting concrete will be strong in proportion as that limestone or trap rock is strong.

Many people have an idea that there is a chemical reaction between the cement and stone. That is not the case. The reaction which takes place is in the setting or crystallizing of the cement. I have no doubt that many of you are familiar with the experiment of taking common salt, mixing it up thoroughly in a jar, putting in perhaps some sticks and setting it on the stove or in a warm place where the water will evaporate. The salt will crystallize. The crystallization of that salt is exactly the same process that goes on in the setting of cement. Each piece of stone, each grain of sand, is made up of a series of microscopic pores or small holes. There are pores in each piece of stone, just as there are in your block. A very dry-mixed block may be porous, as you know. That porous block is an intensified condition of what you find in the stone. Now, this cement in its plastic condition flows into these pores and sets, and this little anchorage is what binds the particles one to another.

Mr. Sherer: To return to the question of aggregates, it seems to me that the locality and the quality and kind of material

that is available in order to make your blocks on a commercial basis is a very important matter and should not be overlooked. We find many localities have much better sand and are better equipped in that particular than others, and I have used a great number of aggregates at different times in making blocks. Some of them produce better blocks than others, and, as I say, that while we want to make blocks, we also want to make some money. Therefore it is necessary to use the aggregate that will do, and that you can buy for the least money. In speaking of the limestone ordinarily, as has been said, there is such a variety of limestones, some are very soft, others very hard, and you should designate the kind you have in use. We in the city of Milwaukee have erected some buildings that our building inspector or building department are testing. I had hoped that this test would have been completed, so that we might make you a report, and we may do so before this convention is over. We in Milwaukee generally make our blocks of sand and cement pure and simple. Some of us use a small quantity of stone. In using the sand, we endeavor to get several sizes, so that we can fill the voids as nearly as possible. Some gentlemen think an amount of clay is necessary. It seems to be the consensus of opinion of men who have made a study of cement and its uses, technically as well as practically, that the cleaner we can get out aggregates the better results we can get. At least that has been our experience.

At the present time I am going through a series of experiments endeavoring to find a short time cure for our blocks, and applying steam for indurating. I find one difficulty in the induration or curing of blocks by steam is that with the aggregates that we have at hand, we cannot make as dense a block as we would like to have to cure with steam; because the more porous your material is the less pressure you must use to harden a block in say 8 to 10 to 12 or 24 hours successfully with steam. We have been experimenting with exhaust steam with considerable success. However, we find that we get a better product when we put a higher pressure of steam and our blocks are dense enough so that the steam does not cause disintegration and separation of our aggregates. In addition I will say that we have been manufacturing for a number of years, and I can say truthfully with success, both artistically and financially. We think well of the block business. It has become quite a portion of our business as

a material firm, which has been in existence for a great many years.

We have been manufacturing cement sewer pipe, using a natural or hydraulic cement and carbonizing it in carbon kilns, using coke and steam. Our results in that respect have been good. We find that Portland cement does not take as kindly to the corbonizing process as the natural cements. At times we have mixed them with fairly good success, but we have endeavored to make good blocks to meet the market, and we have been using principally, as I say, as clean sand as we could get. In our immediate neighborhood the bank sand contains some clay. We use it and we make a good block with it. Sometimes we go to other counties for our sand; for instance, for the last year we have been getting a good silica sand, a bank sand, from Rock county, and we obtain much better results than we ever did by using our native product around our city. The reason is because it is so much cleaner and of different sizes. The sand in itself ranges from extremely fine sand to a coarser grain, perhaps, say, a number 4 or 5 shot, and we find the clean silica sand the best. As we get good clean bank sand in our vicinity we seldom use any stone in our mixture. We have done it at times but we can make a good commercial block out of our sand and cement.

Mr. Pierson: Will you tell us just how long you cure your blocks after they leave your machine, and how you do it?

Mr. Sherer: We work in the winter time in an enclosed building which we keep heated to about 65 or 70 degress Fahrenheit; we allow our blocks to remain inside for perhaps three days before placing them on the outside in the weather and in the winter time give them little or no water, allowing the atmosphere to cure them. If it is not too cold we wet them perhaps once or twice after putting them out, or, at the time we put them out. During the summer time, of course, we leave them 24 hours and then remove them to our yard, and then immediately commence to wet them. The wetting of the blocks is generally governed entirely by atmospheric conditions. Some days they will require thorough wetting 3 or 4 times; other days when the atmosphere contains plenty of humidity once is enough, and if it is rainy and damp for two or three days we don't wet them at all, and we think these conditions are entirely governed by the temperature or atmosphere. For instance if there is a dry wind blow-

ing and the atmosphere is very light and dry, then we have to wet them more. That is evident, and will show itself on your blocks. Immediately that they commence to dry too much on the outside they will grow lighter in color and you will know at once that they need water unless that light color is caused by efflorescence, which is sometimes the case. The wetting of the blocks, I think, should be governed entirely by the temperature and conditions.

Many people ask me if we put our blocks in the sun. We do. We don't care whether we put them in the sun or under a shed or anything of the kind, but if we put them in the sun we must give them a great deal more water because the moisture of the block is drawn off a great many times before crystalization has taken place as it should. We have no hot air.

Mr. J. W. Pierson: In my endeavor to make concrete as well as money in the last few months I have learned two or three things which might be of service, perhaps, to some one just starting in business. One is the turning of your material, particularly if it is turned without any aggregate. I think the mistake which we are all very apt to fall into is an insufficient mixing of our sand with our cement, thus not giving the cement an opportunity of doing its full work. I have a tub mixer, and I mix my material four minutes dry, or until all evidences of the cement have been lost and then mix it 2 or 3 minutes before I put in my water then mix it perhaps 3 or 4 minutets after my water has been added. Another point is the question of measuring or weighing your sand when it is wet. We are very apt to adopt a standard of mixing 1:3, 1:4, or whatever proportion we wish on the basis of dry sand, and we overlook the fact that when that sand is wet we are using more cement than is necessary, because when we are using perhaps 300 pounds of dry sand we will be using about 250 or 240 pounds of wet sand, therefore increasing our proportion of cement needlessly. Another point is the question of water. In my plant I have found in the winter time particularly, that the water was entirely too cold, and delayed the set of the block. I was able with my arrangement to discharge some 500 gallons of hot water which I had used in cooling my gas engine, into my tank. I am able to get brook water, which is very soft, and perhaps the best for that purpose, and I dis-

charge the hot water into my tank or cistern and am thus able to govern the temperature of my water.

Mr. Stephens: Last year in Indianapolis the question of water proofing blocks came up, and I found that the block business was hurt all over the country because people had trouble with damp cement houses. I have noticed in a good many places that blocks were not properly handled after they were made. They would run them out and probably dampen them a little bit and lay them up in the wall, and the consequence was they have had damp houses. I have seen houses that have been up for fifteen years that have never shown a damp spot in them, and I don't think ever will. The great trouble with too many people in making blocks is that they wish to get it done too quickly.

Mr. Pierson: You lay then great stress on the curing of your blocks?

Mr. Stephens: After they are made. A block always hardens from the center out.

Mr. Driscoll: I wish for the information of the delegates, Mr. Stephens would state what that method of curing is; what especial care he takes of his blocks; how does he house them, how much water does he use? Give us some basis, so we will know what he is talking about.

Mr. Stephens: The first 24 hours we keep our blocks under cover and taken care of. We then turn them off, thoroughly wet and keep wet for three or four days. We have one plant at Dayton, Ohio, in which there is a cement tank filled with water. We load the blocks on a truck and take it through the tank, thus saturating the blocks.

Mr. Pierson: How old are the blocks then?

Mr. Stephens: They are 24 hours old. They are turned off the pallets and loaded on the truck. They go through the tank and the water does not only get on both sides but it soaks them. They are probably 2 or 3 minutes going through the water. When you get them out they are like a sponge, thoroughly filled with water. They are taken out in the yard and unloaded, and for two or three days they remain wet. This gentleman spoke about his cold water awhile ago. My experience has been the slower a block dries the more compact it is.

Mr. J. W. Pierson: I put my blocks on cars as soon as they the made and leave them for some time, 10 or 12 hours, before I

wet them. Then I give them a very light spray and after they are 24 hours old I keep them constantly wet by hose. At night I attach some 5 or 6 rotary sprinklers, such as you might call lawn sprinklers and leave them running all night, so that my blocks are constantly wet for five days. Then they are taken outdoors. They are not exposed to the air or to the sun, or to any change in the temperature until they are 5 days old. I don't believe any blocks are put out under that time, no matter what they have gone through with before.

Mr. Chas. Mankedick. The way we have cured blocks depends altogether upon the weather and season of the year. Sometimes you can take them outdoors with little or no attention, and at other times you will have to have more water. Cement curbs I cover with soaked jute bags and I think that is about the best block hardener I know of.

Mr. Robert Gill: I went into one plant where they were using very fine crushed stone screenings. It was quite soft, and probably a limestone since it was in St. Louis. The man in the stone quarry making the blocks made the statement, "These screenings have in them something of the same nature as cement; therefore it is a good material to use in a block." I would like to ask if it is a fallacy, or if there is a foundation for that statement?

President Humphrey: I don't know that I can answer that question. I know that it has been contended that the effect of the fine dust in crushed limestone is to accelerate or rather to intensify the hardness of a concrete. We all know that limestone over which water drips will eventually be dissolved, and we will find carbonate of lime form at some other point in the shape of stalactites and stalagmites. Just to what extent it takes places in concrete I am unable to answer. But I do know from a lot of tests which I have personally made, that limestone dust in concrete seems to give an additional strength to it, but I am unable to say why.

Mr. Gill: That satisfies me on that point. Somebody spoke of the use of hot water in curing a block or in making the block. I would like to ask anybody who has had experience what the effect of that is in winter?

Mr. J. W. Pierson: You misunderstood me. I did not say hot water. I said I discharged 500 gallons of hot water into

a cistern. I should have stated that that cistern holds 5000 gallons, and therefore it does not increase the temperature so that it will be hot water. I should also state that I only do that in the winter time. In the summer time I discharge the hot water back into the brook, and it is only in the winter time that I use it to bring the temperature of my water up to perhaps 60 or 70.

Mr. Gill: What would be the effect of using lukewarm water, or a little warmer, on the curing of the blocks?

Mr. Pierson: It would probably have a beneficial effect at this time of the year.

Mr. C. E. Martin: My experience with blocks covers this year. During that time I have used different kinds of sand, that taken out of sewers, bank sand and screenings, and I would say that my choice would be screening dust; not screenings, but very fine particles mixed with sand. I find that the season of the year has a great deal to do with the curing. During the summer season these gentlemen are perhaps right about the methods followed. Last winter I made blocks in a basement and never thought of touching water to them, and I had just as good results as if set in water a number of days

Mr. Pierson: Was it a dry basement? reasonably dry. Had it a furnace?

Mr Martin: There was necessarily a certain amount of dampness. I never thought of putting any water on at this season of the year, and I will defy any man to make a better block.

Mr. Lesley: There are two things in connection with lime that may be of interest. In the first place with reference to the use of limestone aggregate, there are some tables of experiments made by the British Army Engineers, with reference to the use of sand stone, trap rock and limestone, where in every case the concrete with limestone gave better results. Some experiments by Feret in France are also familiar to all of you; and at Lafayette College experiments were also made on this subject, and in every case limestone in concrete proved to be the strongest. It is further evidenced by the experiments that Feret made on permeability, where he found that in a large concrete wall a pressure of water would eventually go on through and carry lime particles through with it, and ultimately seal the wall on the far side. In other words, it is recognized that lime does eventually disengage itself from the aggregate both in the

cement and the concrete itself. Whether it has a settling quality or not has yet to be demonstrated.

Mr. Pierson: One gentleman touched on the methods of mixing. What kind of mixer do you use? Tell us just exactly how long you mix, how necessary you consider the mixing process to the success of your blocks and how the lack of it has contributed to some failures you know of.

Mr. Philip Schaller: I believe in mixing thoroughly dry, and very little wet. I think it hurts the mix to wet it. Don't mix too much after you have added your water, but keep mixing while it is dry and see that the aggregates be dry

Mr. Pierson: Has any one any apparatus for reducing our sand and aggregates to an especial degree of dryness any kilns or ovens, or anything of that sort? We are coming to that now very soon. We have got to get to that I firmly believe, so that we can know what we have been doing. Do you mix by hand?

Mr. Schaller: I mix three times dry and twice wet. Turning with a shovel.

Mr. B. K. Kramer: I turn it until I know it is thoroughly mixed. I say that, because when the sand or material is dry it mixes more readily with the cement than when it is wet. Therefore, if the gravel or the sand is wet you must turn it more. You must be able to judge when it is properly mixed. Take a shovel and rake over the top of it and you can easily tell when it is properly mixed. I mix it by hand. After it is thoroughly mixed and wet we then turn it a couple of times though we do not think that the turning affects it.

Mr. J. R Gill: I will go into detail about mixing by hand. I use a mixture of gravel and if possible two grades of sand, and I am very particular about teaching the men when they start into so handle the shovel that every shovelful will get a thorough mix. Put on the material, say fine sand first, the bulk of the cement on the sand and give them two turns, teaching the men on each side of the pile to shovel from the end of the pile so as to get the maximum amount of tumble as each shovelful is thrown, and spread along the pile by a little twist, thus getting the top layer thoroughly mixed. I mix twice with fine sand with, say three-quarters of the entire amount of cement. That gives a pretty fair mix with two turns; then I put on my coarse material and add the rest of the cement and I get better results with

less labor than to put on the entire amount of cement with the entire aggregates to start with. Four turns, sometimes three and sometimes two turns, but in every case I insist on holding the shovel so that it is taken off the end and spread along in layers.

Mr. Pierson: Is your sand always dry?

Mr. Gill: The amount of water, of course, will depend upon the aggregate.

Mr. Pierson: Would you turn it more when wet?

Mr. Gill: Once, when it is wet. It is my opinion that when it is wet it is a disadvantage

Mr J. P. Hall: The mixing I do may be called all by hand. I spread my sand to a depth of about 4 or 5 inches on my floor, putting my cement on top of it, and spreading that also, I then have the ordinary mason's sandscrape, which you know has sides. I nail two more boards on, one on the side and one on the top, so that it is actually a double-faced screen, and can be usd either way. I have a piece of canvas nailed to the top of the sand screen that falls from it to the floor. The screen is supported by two pieces to the ceiling of my shed When my sand and cement are spread I merely take this sand and cement on shovels and pass it through the screen. It does not fly a great distance, because it hits the canvas and falls down in a pile. After it has passed through the screen once we merely throw the screen back, throw the canvas over and pass it through the second time. The passing of the sand and cement through the screen twice gives the most thorough mixing of any that I know. After it has passed through the screen we wet it, turn it over twice and it is ready for use. I think if any one tries that they will find they will get as good mixing that way as it is possible to mix sand and cement.

Mr. Pierson: I saw one plant where a man nailed two screens between his mixing board and his machine, and the man had to send it through these before he could get it to the mixing board, and he said he didn't know but what some one put a third one in so as to insure a better mix.

Mr. H. G. Goodwin: When we started into business we tried a continuous mixer. That worked successfully as long as we would mix our materials dry, but we didn't have success in adding the water. Afterwards we discarded the continuous mixer and mixed by hand, along the lines described. In my neighbor-

hood a white silica pebble comes out of the quarry in large chunks and is very easily broken. By simply taking a shovel or hammer it will break up into fine particles. The proportions in that pebble as it is found naturally are almost the ideal proportions for a cement block. You have the fine sand, the coarse sand and the small pebbles ranging all the way from 1-4 up to 1-2 and sometimes 3-4 of an inch. We sometimes grade by screening, to be sure we get our proportions right. We mix our fine sand and our cement thoroughly together, add the coarser aggregates, spread it out as was suggested, on a platform, and sprinkle by hand with a sprinkler, at the same time raking it back and forth. We shovel but twice after that; turning thoroughly and then shovel into a pile. In regard to the curing, how soon do you add water to the block after it has been made? We give the block water just as soon as possible.

Mr. Pierson: How soon is that in the summer time?

Mr. Goodwin: I have been able to give the block water successfully within two hours and sometimes sooner.

Mr Pierson: That is under cover?

Mr Goodwin: Yes, and I think that the curing is the most important point in the manfacture of blocks; in fact is just as important as the cement you use. And I have had better results from taking care in the curing of my blocks than I have had from any other part of the work. The question is simply to be able to impress on your men the necessity of watering the blocks just as soon as it is possible to give them water, and to keep that up, especially the first day.

Mr. E. S. Larned: The question of mixing is one of the most important in the success of concrete work. And especially in the manufacture of blocks. The difficulty is extremely exaggerated if you are using fine sand; and still further if you are using crusher dust. At one time I made some tests on different sands in work and I was very much surprised to find that crusher dust, in which the dust would pass one-quarter inch mesh, that 25 per cent of that passed the one hundred mesh. It is an excellent material, but requires very earnest, energetic and hard work to secure good results. The proper mixing of the various ingredients used for the manufacture of blocks is the most important part of the entire work. I have been surprised at the great variance of practice existing between different manufac-

turers in the mixing process. Some will turn the mixtures twice and then judge it by the color, but after it is turned down in to the cone, if you cut down through the middle of that with a spade and lay it open and look down at the surface you have exposed, it is a very common thing to find rivulets of clear sand through the mixture. It is not exactly dangerous, but at the same time, unless you have got a thorough mix between your cement and sand you will not have a uniform product. Where a large block of these are distributed over a yard, it is almost impossible to get an even mix, and you will have a batch that will vary from 1 to 1, to 1 to 6.

You all know that in applying water to the cement the tendency is to make it lump. In that condition it is of course, almost impossible to mix sand through it. A very good practice is to have your sand and your cement thoroughly dry before they are mixed with the water.

Another thing very important is the gauge. One man will use wheel-barrows and one will use barrels with the heads knocked out, and another man will make a box varying in area from 32 to 9 feet square. In using a large box it is very easily heaped up a trifle, but this trifle in heaping is apt to make a great deal of difference in the appearance of a product. In the work on the Metropolitan Subway we made a box three feet square, and we held that uniformly. In measuring cement it is not advisable to measure it in bulk. In Taylor & Thompson's book it is recommended that 3.8 cubic feet be called the contents of a cement barrel. It is a very convenient figure to use, because the barrel weighs 380 pounds, making 100 pounds to the cubic foot The foreign barrels run from 3.17 to 3.25 cubic feet. The American barrels run from 3.38 to 3.47 cubic feet, according to investigations of members of the American Society of Civil Engineers and it was further found that the cement barrels are very seldom filled. They are packed tight, but not filled to the top. In your mixing you must have uniform gaugers in order that you may produce a uniform result.

Mr. J. P. Hall: I have been asked to explain the manner in which I mix sand and cement in making blocks. The materials of which a block is made depend entirely on the locality in which you make them. Some of you gentlemen are able to get crushed stone screening crusher dust from the quarries. Others can

use gravel and sand. In my locality the cheapest article that we can purchase for the manufacture of blocks is a washed screened sand, therefore my block is made entirely of washed screened sand. The method of handling is this: I have a concrete floor laid, and on that floor I use two boxes. One box contains 4 cubic feet divided into two parts with partitions between them. The other box is the same size, but it is divided into three parts, so that I could use one, two, three or four parts in the measurement. I proportion my sand for one bag of cement stirring it on the floor after measuring. I use 4 of sand and one bag of cement. I have one man who does nothing but measure the sand and put on the cement. I also have him turn it over once. It is then turned over four times, which seems to be sufficient in the ordinary block. Where I want anything very fine I pass it through the screen the same as I was telling you last night. After turning it over four times it is then again spread out and wet with a watering can. I have tried hose, I tried sprinklers from the hose, and I found that it didn't work just right. You get too little or too much water. By using the watering can the man can put on just sufficient water so that he gets about the same composition at all times. Our manner of telling that is, of course, as you know, by eye. A man gets accustomed to it and can tell almost by the condition of the sand about how much water to put on. The actual test practically is merely taking a handful of the mixture as it is mixed and pressing it in your hand, and opening it and giving it a little shake. If it does not spread, still adheres together, you will find you have got pretty near the right mixture. In all our block machines if you get your stuff too wet you all know it will stick to your molds. If you get it too dry you get a ragged looking block. In mixing only one bag to four of sand at a time I have a continual fresh mixture going into my machines at all times. We usually clean up at noontime so there is nothing left over, and the mixers start a little before 1 o'clock so as to keep the material going and keep it entirely fresh. We thoroughly tamp it into the machine, take it out and place it on cars. During this time of year we allow our cars to lay under the shed for four days. As regards the wetting of the blocks, that is merely a question of judgment. It depends entirely upon the temperature and condition of the weather The blocks, after remaining in the shed about three days are placed outside. When

the temperature is at all warm in the morning, during this time of the year, we soak them thoroughly with water. If it is freezing we don't touch them. Last winter I tried different methods of watering my blocks on the outside. I found it made very little difference after a block was 3 or 4 days old, whether you put water on in freezing weather or not. I have taken blocks out and wet them thoroughly, put them in a place where the sun could not strike them, and they would remain frozen, and those that are practical builders here know that in plastering, if you plaster a building and allow it to freeze up and remain frozen until it freezes dry, the plastering will remain good, whereas, if it freezes and thaws then you have a rotten piece of wall. It is the same with the blocks. You find that in freezing weather on all concrete matters that if it is properly protected with even a light covering of something frost seems to affect it very little. On a dam in New Jersey which I presume is one of the largest concrete dams in the world, we had a standard that we never worked when the thermometer was below 20, but we would work and put in concrete work with the thermometer at 20, and in covering it we merely covered it with either tar or the ordinary building paper over night, and went right on the next morning; and so far we have had no disturbances with frost. But that is disgressing from the mixing question.

If the sand is entirely too wet, which it will be of course if exposed to heavy storms, I found that a number of my blocks seemed to be spotted, that is, all over them were a number of spots much darker than the rest of the block. I would make blocks in the morning that would be all spotted, while those made in the afternoon seemed to have a clear, even face. I found that the cause of that was due to using the sand when it was entirely too wet. The small atoms of sand seemed to make a little ball of cement and when the ball was made and compressed against the plate these little balls of cement would press out, and when the ball was dry you would get a block of a great many different colors, depending entirely upon the substance of which the ball was made. What I mean by that is, that in almost all sand you have got some foreign substance, and the small particle of clay being covered with a thin film of cement and pressed against your mold will bring out a yellow spot. If you get something that is more like soil, that is black, you will get a black spot and you will

find different spots on your stone if you use your sand entirely too wet. The proper method would be to keep the sand dry if possible. If you can keep the sand entirely dry at all times I think you will get a very clean and even colored block. If you do not you will get a spotted block.

Mr. Boynton: I would like to ask if he is in the habit of drying his sand, reducing his materials to some standard before beginning mixing. It seems to me that would be very important.

Chas. Mandekick: We always try to keep our sand dry and then we can put the water on as needed later on.

Mr. G. J. Hamill: In a great many ways I have to differ with Mr, Hall as regards wet sand producing spots, I do not believe it makes any difference whether your sand is wet or dry if you are going to wet it anyhow. At least in the wet process. I believe that in mixing wet, water dissolves the cement, makes a solution of the cement, and by taking a solution therefore it goes through all the particles and voids of even the sand, which is the next finest thing we have and it therefore coats every particle of sand. No doubt you are not able to release these molds as fast as you can with the dry process, but with a number of molds, I believe I am making as many blocks per day as I hear any of my dry competitors boast of. I believe by adding water to make the composition of a consistency of bricklayers mortar; that you get a more solid block. The water crystallizes, hardens the block. You are giving the cement the water at the proper time, while it is acting, Of course the adding of water afterwards as many times as you choose, is a benefit, and the only point I can lay stress on is the forming of a solution of the cement which coats every little particle of sand, whereas, if it were dry the sand will bridge and not become so close and dense, no matter how much you tamp it. Of course you must not add to much water, just enough to make a plastic mortar.

Mr. Hall: I would like to say the gentleman does not differ with me at all. When I was stating how I mixed my material I forgot to say that I am using what is known by most of us as dry process or semi-dry process. If we can get a mold for making blocks in which we can make our material the same as mason's mortar, or if we have sufficient ground space so that all of our blocks could be made by the wet process, we would

all get a more dense, a stronger and a better block in every way. And when I spoke about wet sand I was speaking about a sand that had an excess of water in it, caused by storm or something of that kind, and attempting to use that sand in what I call the semi-wet process. So that the gentleman does not differ with me. You will find that if you have a very wet sand, as I say, and attempt to mix that very wet sand by the semi-dry process you will have these spots that I was speaking of. If I had my way in using concrete I would make it very soft. In works I have been on I have known the concrete to be so soft that it was not necessary to do any tamping. The only tamping that was done was by men wearing hip boots, and the concrete was all cast in forms and in a great many cases the proportions ran up as high as 8 to 1, and in order to get a facing on it the ordinary potato fork was used, pressing it down the face of the mold and drawing the large stone slag or whatever away from the form, leaving a smooth space. The entirely wet process will give a better block, but as I understand it the majority of the men are not making the wet block. They are making a dry block, and that was what I was endeavoring to explain.

Mr. S. H. Gill: If you have got a percentage of water let us hear it, so that we can know definitely.

Mr. Pierson: I would suggest that it makes a great deal of difference how wet your sand is when you begin to work it. I have seen sand you couldn't put any additional water in at all, because it is so wet, right after a storm.

Mr. J. Schall: I believe that in mixing concrete consideration should be given first to the water in the sand that you are using. If you use a wet sand you certainly have to mix it a great deal more than with dry sand to obtain an even color.

In regard to the spots the gentleman spoke about, I find that those black spots result more from the cement than anything else. If you have some cement that is clogged and it is not thoroughly mixed you get some cement in the box and that makes those black spots.

Mr. C. W. Stevens: Speaking of sand being wet, we found years ago that if the sand was wet before we mixed it with the cement that we did not obtain the same results that we did if the sand was dry. We found the same results in limestone. Some 20 years ago I was making stone for a house, and there

were two window caps, arches, that we did not make, and during the night it rained. The next day we made them and the sand was very wet. They complained to me about the stone never drying. Those two caps after a rain would hold the moisture, while the rest of the stone in the building would dry out, I begun to experiment from that, and we found the results were much better where the sand was dry before the cement was mixed with it. We had a case in our factory some two years ago. There was some limestone that was wet, and I told the foreman not to use it, that he could not get the same results. He mixed some of it with cement and when we came to rack that stone by hand we couldn't use it. It would not crystallize. We never wet blocks after making them. We use the wet process and we find if we wet blocks continually, even in the shop, they are liable to hair check. We get a uniform color, keep them damp, but never wet them. Of course the shop is damp. For the last three years we have not wet our blocks at all and we get a perfect crystallization.

Mr. Mandekick: In regard to the coloring of the cement, there is one point which has never been taken into consideration that I find makes quite a difference and that is the water that is used. In cities where they have wells, water out of one well would make a dark colored cement, and that from another would give a light color. The most preferable turned out to be those that had pure rain water on them. In mixing care must be taken not to have it too wet or the cement will wash off the pebbles.

Mr. F. H. Gill: I would like to get an answer to my question, what percentage of water do you use?

President Huhmphrey: It depends upon the dryness of your sand. If you can reduce your sand to a unit of dryness then you can determine the percent of water required. Otherwise you will have to use your judgment in each batch.

Mr. R. Schulz: In regard to adding a certain percentage of water. I have used in four cubic feet of sand 100 pounds of cement and 6 gallons of water. The sand was perfectly dry and when I could not get the sand as dry as this, I have added sufficient water to make the mix. In a dry process block and in a dry mix you must have your sand as dry as possible. If the sand is too wet it will cause these cement spots on the surface

and in the body of the block. One time the men left some sand out in the rain during the night and mixed that up with the cement the next morning. They did not mix it thoroughly enough and the blocks were all spotted. Some of them I left to set, and after they were dried out I kicked them to pieces with my foot and the sand ran out between the spots.

Mr. J. H. Twitchell: I hardly know what to say on this mixing question; we are using a continuous mechanical mixer, and I find the same difficulty, spotting where the sand is wet. However, I have under cover a stock of 3 or 4 carloads of sand, and as my shed is well heated that sand is dried to a reasonable extent, and the trouble is not so noticeable, still where I run a little short of sand and have to use it direct from the cars, I find it quite noticeable in blocks.

Mr. Hall: When the price of Portland cement was in the neighborhood of $2 a barrel in New York City we had a company there known as the Silica Cement Co. They purchased cement on the market and reground it with sand. They had two classes of cement known as No. 1 and No. 2. The No. 1 cement consisted of Portland cement mixed with one part of sand and reground, and their No. 2 consisted of one part of Portland cement and 2 parts of sand reground. This was put on the market at a cheaper rate than the ordinary Portland cement, and when the laboratory tests were made on the silica cement they found that the strength obtained was about 15 per cent. less than the original cement. Now that brings up this question: Will not the mixing of the sand and cement together dry in the proportions in which we usually mix them and regrinding to a powder make a much better block than by merely mixing the sand and cement together? If a man has a plant properly arranged, the drying of the sand, the mixing of it mechanically, the regrinding of it, and the wetting, will cost but very little more for the mechanical process than it costs us now.

Mr. Joseph Schall: If you use ground sand and cement and put it into your machine it will stick. You can use about half the amount of water than you can use the way we do it now.

Mr. Peirson: What sort of sand do you use?

Mr. Schall: Torpedo sand.

Mr. Pearson: Can anybody give us any light on the coloring of blocks?

Mr. C. W. Stevens: We have been coloring for the last 20 years. We have a great many buildings put up 20 years ago with the colored blocks, brown and red. Several of our companies used coloring that we could not recommend and they had some trouble with them. Those buildings are as good to-day as 20 years ago when they were built. The basis of the color depends upon your aggregate When we used a red stone it took less. With red stone we use about 1-10 part, and in a white stone you have to use a little more. If you use red granite it takes somewhat less. In any case it depends a great deal on your aggregate. I would like to say one word about mixing. I visited one of our plants a short time ago when they were mixing different from any mixing that I had ever seen done. They first put the water in their mixer then their cement, which they stirred thoroughly, then their aggregates. Their results were excellent.

Mr. W. J. Scoutt: In mixing coloring matter with facing material when we face our blocks, we have found it practically impossible to get a uniform color for the facing material unless we grind the coloring matter with the cement itself; so that the cement we use is a colored cement, rather than color mixed with aggregate. In that way we have been able to get an absolutely uniform color to the block. I judge from past experience with a number of companies, that the color of cement very largely determines the color of the block. If we don't coat each particle of the aggregate with the cement itself we cannot get a good bond. They must be covered and covered absolutely, so that the color of the sand or the color of the aggregate has very little influence upon the final color of the block. We have used a white silica sand 99 and a fraction per cent. pure silica and as white as snow, and at the same time with the same quality of mix as to percentage of water and cement and aggregates, a torpedo sand that was almost the color of gravel, ground. The ultimte color of the two blocks was almost identical, because the cement itself gave us that final color. As Mr. Stevens said, the percentage of color necessary to determine or obtain any special shade depends upon the strength of the coloring matter. The reds are much stronger than the others. One gentleman ask-

ed regarding the use of damp crushed limestone with a considerable percentage of powder that would adhere to the coarser aggregates. In the use of such aggregates it has been my experience that unless the mixture be sufficiently wet to practically liquify the cement, causing it to flow and to wash off that slight coating of fine dust, there is not a bond between the cement and the coarse aggregate, and when such blocks are broken the coarser aggregates will pull out and leave a cavity. The stone when it does pull out in that way is practically as clean as a piece of washed stone, leaving in the cavity this slight coating of the powdered limestone, showing that there could not have been a good bond between the cement and the aggregate: on the other hand, if you use a washed aggregate, and then have your mix sufficiently wet to form a bond between the cement and washed aggregate, you get an absolute bond, and when you break such a stone you cleave right through the aggregate itself, showing the bond in such instance to be very much stronger than the strength of the aggregate itself. This is true if we use a coarse, hard granite, you might say, gravel. You break the gravel stone itself when breaking the concrete block.

Mr. C. W. Stevens: Speaking of grinding mineral with cement, we have always found it practical to put a lot of cobble stones with the coloring matter and the cement, mix them thoroughly and then sift out the stone. It is inexpensive, since you can use your mixer as a grinder.

Mr. Joseph Schall: I would like to hear if anybody has ever made a green stone, and what green he used.

Mr. C. W. Stevens: We attempted it once. We couldn't find any other way to do it, and we put in Paris green. We had fairly good success.

Mr. Hall: I will give you a little experience I had in coloring some mortars. The difficulty with all red mortars is that they will fade, and I attempted to make a mortar that would not fade. I think I succeeded. The building has been up some 20 odd years, and the color is about the same today as it was then. My method of mixing the mortar was this: I used English red oxide of iron which of course is more expensive than our American Spanish browns or hematites, made my mortar, mixed my coloring matter with it, and allowed it to stand for about three weeks. When I tempered the mortar down for use I took sev-

eral hogsheads of water, containing about 50 or 55 gallons of water to each hogshead, and I put into each barrel 50 pounds of copperas. The mortar was tempered with that water and the building has been there now about 20 years, and I think the fading of the color has not been more than one or two very slight shades. So that seems to show that the use of copperas in the water will set the color so that you will have very little or no fading.

Mr. Pierson: Mr. Hotchkiss, can you give us some good leaders about waterproofing?

Mr. Hotchkiss: I use several different water proofs that are on the market, and I will state frankly that the chief objection to them is the price. In order to compete with Chicago block prices we had to get a cheap waterproof. In order to do that I used hydrated lime and we only use it for the facing. We rigged up a tank, deposited our lime in the first place for two weeks in the tank, stirring it every day, and sprayed it on the mix. The chief trouble in the mixing is in the spray. As it revolves there is a small pipe that enters the center of the shaft and is drawn out. Of course when I stirred the lime in the barrel and it went in it clogged my hose. But we found that by using a lime water to wet our facing material that it made a very excellent waterproof face. We used about one bushel of lime to 50 gallons of water, and then we found that was too strong and simply refilled the barrel again. We did that three times so it would be one bushel to 150 gallons of water, which makes a very good waterproof face.

Mr. C. E. Lanzer: How permanent will such a finish be?

Mr. Hotchkiss: I think as permanent as natural stone.

Mr. Pierson: I think the principle is that the water carries the particles of lime into the fibre or texture of the block, and it remains there and assists in filling the voids.

Mr. E. F. Arn: I would like to ask what difference in the per cent of water absorbed there would be in a block made without this lime or with the lime.

Mr. Hotchkiss: During a heavy rain storm the block that does not have hydrated lime in the face will hold the moisture that shows on the outside of the building for several hours longer than the one that has the hydrated lime. You can hardly tell the difference during a rain storm. The wall of course looks as

though a pail of water had been thrown against it, but the water does not seem to go into the block any more than it does into an ordinary stone building.

Mr. Driscoll: I read the Newberry formula giving the relation between density and strength for different proportions of lime. I experimented with it ,and am satisfied that you make a stronger block and one that is as nearly waterproof as it is necessary to be.

Mr. S. B. Newberry: We have been in the concrete block business for a number of years in the city of Cleveland and were the original blockmakers there. As long as two years ago, we adopted hydrated lime as an addition to the block mixture and found that the best results were obtained by making a 1:4 mixture of cement and sand. I ought to say that our material is really a coarse sand. We could use, if we had plenty of coarse gravel available, a 1:5 mixture with equally good results, but using a 1:4 mixture of cement and sand we found it was best to replace 1-4 to 1-3 of the cement by hydrated lime; that is, instead of using 150 pounds of cement and 600 pounds of sand which with us makes a mix for our mixer, we use say 112 of cement and 38 of hydrate of lime, or 100 of cement and 50 of the hydrate of lime and 600 of sand, and it gives blocks that are waterproof enough for all practical purposes. We ought to remember one thing I think; that absolutely water tight blocks are not necessary and are not even desirable. A certain amount of porosity in walls, such as that which is obtained with a brick wall or a stone wall covered with ordinary plastering, is desirable and necessary. If you have a wall made absolutely water tight, a wall made of glazed terra cotta tile you will get sweating or condensation of moisture on the inside; dampness on the inside coming in contact with the cold walls will deposit moisture unless the walls are porous enough to absorb and carry it away. As regards the penetration of water from the outside, the question is rather the speed at which the moisture enters the block, rather than a question of absolute water tight qualities. If the block only very slowly absorbs water from the outside during a heavy rain, it will only be partially penetrated, and then when the rain ceases it will dry out again and you will never get moisture clear through to the interior, and further, the moisture penetrates more and more slowly as it encounters greater resistance at a

greater distance from the surface. Of course there are various other methods of water proofing. The first thing to be considered in making a water tight block is to use the right kind of sand and gravel and to have plenty of coarse material; and exactly as Mr. Gibson said in his paper that was read before us last night, to reduce the voids in the mixture to the lowest possible amount. You will be surprised what a difference in the amount of voids is caused by using a liberal amount of coarse material in the mixture. The second essential in getting water tight blocks is to use plenty of water in the mixture, and I am going to harp on that just as long as you will listen to it, because I believe that is the fault with 9-10 of the blocks that are made. They are not made wet enough to give the greatest possible density in the mixture, and to give the cement a chance to harden thoroughly. A great many writers on the subject have talked about the sprinkling, and the fact that they are allowed to dry out. There is not very much in that. If the block is wet enough, to start with and has got down to the full density, and the cement is thoroughly plastic and coats the particles, what is done to it afterwards is of much less consequence. It is certainly proven by positive tests that alternate wetting and drying is the most effective way of hardening cement and that blocks which are sprinkled again and allowed to dry out will get harder than they ever will if they are kept permanently dry. So I don't believe blocks are generally injured very much by more or less sprinkling, and I don't believe they could be very much benefited in that respect, but I do believe that they could be doubled in quality and improved enormously in water proof qualities, appearance and everything else, by making the mixture just as wet as it can be and still have the block come at once out of the mold. There are water proof compounds on the market and we are in the water proof compound business ourselves, but I suppose I had better not say much about that. There are water proof compounds on the market that have the effect of making the block turn water like a duck's back; that is, repel the water. A small quantity of such material as that is all that is necessary to give the block the necessary water proof qualities, providing you cannot get those qualities in other ways. I would not say that it is always necessary. If you have a suitable sand and gravel, and if you use a liberal proportion of cement

and make your blocks wet enough you won't need any water proof compound. Certainly you won't if you use a certain proportion of hydrated lime, but on the other hand if you want to make for certain purposes a block which does not require to be so very strong, and you want to economize on the cement, you can get the water proof qualities by using a certain amount of water proof compound. We should also remember this, that the cement itself has a tendency to become water proof with time, and all experiments that have been made show very strikingly, that concretes which are porous and permeable at the start, after a few weeks or months become practically tight, so that we need not have any great anxiety on that account. If there is a slight penetration of water it will soon get over it. In those unfortunate cases where buildings have been put up and found to be damp, where dampness has penetrated, we have found the most effective remedy is a very thin wash of neat cement on the outside. Stir up the cement in water into a very thin grout, and apply it with a whitewash brush, being very careful not to get on too much, because then you will get hair cracks, and unless it is exceedingly thin it will show streaks on the surface which will injure the appearance. It takes a very little cement indeed to turn the water and prevent it from penetrating. It retains the color of the blocks and certainly does no harm whatever to the appearance of the building.

SOME NOTES ON REINFORCED CONCRETE.

A. L. Johnson.

For several thousand years masonry structures have been constructed on the one principle that there must be no tension in the same, compression being practically the only element of strength available for duty. The reason for this was that the tensile strength of the stone or concrete masonry was very low, insignificant, in fact. In spite of the limitation thus put on designers, look at the wonderful structures that have come down to us. Now, suppose that the ancients four thousand years ago had had a masonry that was just as strong and reliable in tension as in compression, what would our structures look like today in that case? Many of them undoubtedly would be upside down and wrong end to, as compared with modern practice. What the ancients might have done under such circumstances it has been left for us to do, for we unquestionably have now in reinforced concrete a masonry construction that is even more reliable in tension than in compression, and we should realize more fully than we do the epoch making character of the innovation.

HISTORY.

The history of the origin of reinforced concrete has been published so often that the speaker will not enter into this part of the subject further than to say that he thinks too little credit has been given to Thaddeus Hyatt, an American, for the work he did in the years 1876 and 1877 in England. He made numerous tests of reinforced concreted beams at Kirkaldy's laboratory, reinforced with bars of different patterns and arrangements, developing at this early date the advantages of stirrups, of having them connected to the bar, of bending bars up at the ends for shearing provision in short beams, and in a general way, the advantage of a mechanical bond, though his investigations here did not enable him to learn the criteria for differentiating the efficient from the non-efficient.

Up to the time of Hyatt very little work in reinforced concrete had been done abroad, other than in tanks, vases, pots, etc., in which the section was entirely in tension, and in which, therefore, there was little tendency for different movement on the part of the metal and the concrete, such as occurs in reinforced concrete beams. Neither had there been anything of consequence in the United States, about the only instance now known being a building constructed entirely of reinforced concrete by Ward in 1875, in the State of New York.

Ransome made some experiments in San Francisco on reinforced concrete beams, and on September 16, 1884, received a United States patent on a floor construction of concrete reinforced with square bars twisted. claiming as advantages over plain material an increase in tensile strength and a more secure bond. Later he applied for and secured a patent on a triangular twisted bar, the contention for patentability being that this bar would not split the concrete ribs in which the bar was embedded, owing to the deeper cupping that would be obtained in the triangular type. Mr. Ransome's theory of the splitting action noticed is explained in the patent as follows:

Assuming a Tee beam,or ribbed floor construction, in which the rib is reinforced with a steel bar, when the floor is loaded, the bar being bent up at the ends, it is as if the rib were held up by the bar, or sitting on the bar. If the floor is loaded to say 400 pounds per square foot, and the ribs are say 3 feet apart, then there is a vertical load of 1,200 pounds on top of the rib for each foot of length. Hence the rib acts as a column, being supported on the bar at the bottom. As the bar is narrow, there is a tendency for the concrete to flow each side of the bar, or in other words, there is a movement of the concrete above the bar, crosswise of same. In a plain bar there would be no obstruction to the movement. In the square twisted bar there was not, according to Mr. Ransome, sufficient obstruction to the movement, as the cupping was not sufficiently deep. Hence the superiority of the triangular type.

The above theory was of course fallacious, and the type never came into commercial use. The vertical load on the rib for any given length is carried by vertical shear in the concrete, and the rib is not acting as a column at all. If it were, in the case mentioned where the rib carried 1,200 pounds per lineal foot,

supposing the rib to be 4 inches wide, this would only give a compressive stress in the rib of 25 pounds per square inch, and would be too small to be noticeable even if many times this amount.

The ribs do not act as columns, but as beams, lengthening on the bottom and shortening on top, and it is the movement of the concrete lengthwise of the bar, which the bar must be calculated to resist, and it is in this resistance that it begins to help carry the load and become an integral part of the structure. To offer reliable and satisfactory resistance to this movement of concrete on the bar it is designed to have on its surface projections, or depressions, the sides of which are nearly at right angles to the direction of the movement, which is to say, to the bar itself. It is not necessary that the sides of these ribs or depressions should be exactly at right angles to the bar to develop this efficiency, however, it being possible to vary therefrom an amount equal to the angle of friction between the concrete and the metal, which, on the average, will be between 30 degrees and 45 degrees. But if the surfaces against which the concrete presses are nearly parallel to the direction of the movement, we have the same action as when an axe is forced into a block of wood, a very heavy splitting component resulting, which may be many times as great as the direct force itself, similar to the action of a toggle joint.

Of course, this splitting action is of little effect until after the so-called adhesion of the concrete to the surface of the metal has been overcome. This adhesion is not really adhesion at all in the sense that two pieces of wood may be made to adhere to each other by means of glue. The appellation has been given to the resistance of a bar against withdrawal from a block of concrete. As a matter of fact, this resistance is made up of two parts, friction and a mechanical bond caused by the entering of cement particles into microscopical pores on the surface of the metal, which particles have to be sheared off in withdrawing the bar. For short depth of embedment these two forces amount to about 500 pounds per square inch of bar surface for bars of ordinary mill surface and for good concrete, where perfect union exists between the cement and the metal. Of this, friction contributes about 25 pounds per square inch, the remaining 475 being due to the mechanical bond. There is there-

fore no reason in advocates of plain bar reinforcement decrying mechanical bond, inasmuch as the plain bar has really no value not contributed by this same quality. This bond, it is true, is of a microscopical nature and not calculated to inspire confidence in structures upon the integrity of which much human life may depend; but nevertheless its value is considerable, and if it would remain intact we could design and execute reliable concrete structures with plain bar reinforcement.

There are a number of things, however, tending to impair a bond of this nature amongst which we may mention the following:

1. Shocks and vibrations continued through years of service are liable to injure, if not wholly destroy, the bond, and have done it in cases under the speaker's own personal observation.

2. Where the concrete is continually wet, the adhesion will be cut down from 50 to 60 per cent in less than one year, as indicated by the experiments of Breuillie.

3. The development of the working stress in the metal slightly stretches same, and the cross section is therefore slightly reduced. Suppose the metal has a working stress of 15,000 pounds per square inch, then the proportionate elongation is .0005, and the decrease in the diameter is, with practical exactness, one-half this, or .00025, a quantity which, though small, could be readily measured by an ordinary micrometer, and certainly is far from microscopical.

The advisability of a reinforcing bar with a more possitive grip on the concrete than that afforded by the roughness of the mill surface of a plain bar, which is of course very slight, is not merely due to the necessity of maintaining continuously the strength of the beam, but also to the necessity of keeping the bars from being exposed to the atmosphere. .

We know, now, that in a reinforced concrete beam cracks begin to form in the concrete on the tension side, at an elongation which gives a stress of from 12,000 to 15,000 pounds per square inch in the bars, which is at just about, or even a little below, the working stress usually employed. If plain bars are used these cracks will be far apart and correspondingly large, while if a bar is used having a positive grip on the concrete for every inch of bar, there can be no accumulation of cracking tendency for a considerable length, but there will be a great many

cracks, mostly visible to the naked eye, until the metal has passed its elastic limit. Such cracks will not be injurious, while the cracks that form with the plain bars might. They amounted to considerable in the tests made about five years ago by M. Considere, as a result of which he reported the wonderful stretchability of reinforced concrete that misled us all for some time. In these tests he bent the beam several times, so that the tension fiber had been stretched from 15 to 20 times as much as plain concrete would stand, then cut a piece 8 inches long out of the middle surrounding the 1-4 inch rod that he used for the reinforcement, and then with great pains and labor cut the rod out of this 8-inch piece of rectangular section, leaving a hole through same from end to end. Now this concrete had been stretched, according to M. Considere, many times as much as plain concrete would endure, but instead of falling apart when the rod was finally gotten out, it was perfectly intact, and he put it on supports, loading it in the middle, and obtained as much carrying capacity as he could have secured with the same kind of concrete which had never been subjected to such severe usage. This seems like proof positive of M. Considere's conclusion. But it developed later that he had taken this 8-inch specimen from between two cracks of considerable size, and that while the rod had undoubtedly stretched as much as assumed, the surrounding concrete had not, the end sections slipping back and relieving the concrete. In other words, there was a slip between the rod and the concrete. If the rod he used had been a rod of mechanical bond, giving a good positive grip for every inch of its length, he would not have had this slip between the rod and concrete.

The distance between cracks on the bottom of a reinforced concrete beam subject to uniform bending moment, may be discussed as follows:

Let d = spacing of bars in inches;
e = distance from center of bar to surface in inches;
f = tensile strength of the concrete in pounds per square inch;
s = bonding value of bar in pounds per square inch o surface;
l = spacing of cracks in inches.

The cracks will come at such distance apart that the bond of the bar for the distance equals the tensile strength of the co-

crete immediately around the bar, having in this respect a close analogy to the distance apart of the shrinkage cracks in a retaining wall.

Then we have for a square bar,

$$def = 4sl$$

or

$$l = \frac{def}{4s}$$

On plain bars with real smooth surface s has been found less than 100 pounds per square inch, though as before stated, for the ordinary rolling mill surface, with careful imbedment, it has a value originally of about 500 pounds per square inch. Assuming an allowance for ordinary working conditions, and for reduction due to shrinkage of bar sections, an average of 250 pounds per square inch where there is no vibration of consequence, and where the concrete is not wet, as it would generally be in open air work, we have:

$$l = \frac{def}{1000}$$

For a mechanical bond bar, such as the corrugated bar, for example, this value will be in the neighborhood of 750 pounds per square inch, a value also which will be practically permanent, and for this:

$$l = \frac{def}{3000}$$

That is to say the latter type would give cracks of only one-third the size that would be the case in the beam reinforced with plain bars, even under the best average conditions. In the case of open air structures, subject to vibration for some years, the disproportion might be very much greater than this.

So that from every point of view it would seem more conservative to use mechanical bond bars independent of the adhesion, rather than plain bars. In any given case plain bars might give entire satisfaction; but the factor of safety after some years' service, would certainly be much less where such bars were employed.

The speaker has often been asked the question, why is it necessary to use bars of mechanical bond when abroad, where their experience is much greater than ours, they use only plain

material? The question is a very proper one, and requires an explanation. As before stated, it is only in beam work that the necessity for absolute bond between the concrete and the metal exists, and in this line of work the beginning was made in this country in 1882. These structures were intended for floors, and to carry people and loads of different kinds, and not vases, flower pots, etc., of which the foreign work up to that time mainly consisted, all of which was reinforced with plain metal. For floors and beam-work in general, plain bars did not seem a rational material to use, just as a common sense proposition; and the speaker doubts very much whether, if the construction of such work had been presented abroad first, the foreign engineers would have considered the use of plain bars either. The natural development would have been to have used a form of mechanical bond first, and *later, if investigations showed it feasible,* come to the simpler and cheaper form of plain material.

In the United States it was like a new problem, and it took the above line of development, at least so far as the point where we think we can come to plain bars, though of recent years some construction companies have taken up the use of plain bars because they are cheaper and because they had foreign practice to point to. But foreign practice in beam work only dates really from a year or two after the organization of the Hennebique Company in France, in the year 1890. Having used plain bars in concrete for vases, pots, reservoirs, etc., for twenty years, when the above company began to build floors and beam work in general, they never thought of using anything but plain bars. It seemed a natural sequence. As a matter of fact, however, the two types of construction are widely different, and they had no right to assume that because plain bars had been satisfactory for constructions in which the whole section is in straight tension or compression, that therefore it would be satisfactory in sections subject to bending.

We have naturally very little personal acquaintance with the work done abroad, and certainly we have learned little of their failures. In a general way we are aware that there have been some, but we do not know the particulars. Of plain bar work in this country we do have examples of failure after eight years' service and we are therefore disposed to be skeptical of the integrity of their early construction in architectural or en-

gineering lines. They have done more such work since 1892 probably than we have since 1882, there being a lull in this country between the years 1887 and 1895; but in the time effect on such constructions, we are far ahead of them. And in the light of our experience, we are not at all prepared to alvocate plain bars as entirely satisfactory and reliable for re-inforced concrete work. And in the last two years there have been signs that a change in opinion toward greater conservatism was taking place abroad. A year ago last May the Prussian Government specifications on reinforced concrete were issued, and they cut down the safe allowable working stress in adhesion to about 30 pounds per square inch, recommending at the same time mechanical bond whenever possible. The above restriction on the working stress in adhesion made it very expensive, and in many cases impossible to use plain material, so that the recommendation in favor of mechanical bond was scarcely necessary. In France, too, much greater care is now taken, the bars being bent up and down and round about in the effort to obtain a better anchorage as well as provide for shearing stresses. In a suspension bridge you can anchor at the ends successfully, but in a reinforced concrete beam, if the bond in the middle, at the section of maximum stress and of maximum distortion, is not absolute, then there will be a relative movement between the concrete and metal, which means an accumulated cracking tendency in the concrete, representing the stretch for a considerable length, so that such beams crack early, but not often. The cracks are few, far apart, and consequently large and damaging, as before explained.

In specifying bars for reinforcement, there are a few fundamental principles that should be observed. In the matter of elastic limit the general proposition is that the elastic limit should be as high as is consistent with the ductility required by the case in hand, up to say 60,000 pounds per square inch. There is no object in having a higher elastic limit than this unless the modulus, too, could be raised, which is, at the present time, not feasible. Preference should be given to more bars of small section, rather than to few of large section, as it is desirable to have the metal well distributed through the stretching concrete area. The bars should not be painted. A slight film of rust is no injury at all, and will totally disappear after embedment. But if the bars

have been exposed long enough for scale to form this must be removed before use.

In designing, the factor of safety which is based upon the elastic limit, should, generally speaking, be four, certainly never less than three. That is to say, the working stress for the actual loads should be only one-fourth of the elastic limit. Many of the municipal building laws are seriously in error in that particular. This will require about three-quarters of one per cent reinforcement for material having an elastic limit of 60,000 pounds per square inch, and one and three-tenths for metal having an elastic limit of from 30,000 to 35,000 pounds per square inch. These are the percentages required to develop the full strength of the section in bending. Short beams, having a ratio of height to span of more than 1-12, will have to have some of the bars turned up at the ends—where they are not required for moment—to take care of the shear. This bending is readily done on the job cold, unless the bars are exceptionally heavy in section.

THEORY.

There are many formulae for the design of reinforced concrete beams, and it is not the speaker's intention to discuss them at this time. Many of these are based upon the ultimate strength of the bars instead of their elastic limit, which is a vicious practice, and should be prohibited by law.

THE USE OF CEMENT AND CONCRETE FOR FARM PURPOSES.

S. M. Woodward*.

Under the general title of rural engineering, that branch of the U, S. Department of Agriculture with which I am connected, namely, the Office of Experiment Stations, endeavors to obtain and disseminate among the agricultural population of the country all information bearing on the various lines of engineering with the exception of road construction, which will be of use to the agriculturist in promoting his prosperity. The greater part of our effort is devoted to investigations relating to irrigation, both in the arid West and the more humid East; to drainage for the removal of alkali from western soils and for the reclamation of overflowed lands, or those too wet for profitable cultivation in the East; and the questions relating to the use of various forms of power and different types of machinery in agricultural operations; we have also given attention to the subject of the design and construction of farm buildings and other structures, among the materials, for which cement seems destined to occupy an increasingly prominent place.

We have been collecting and are preparing to issue in bulletin form information regarding the use of cement in farm constructions in both this country and abroad. It will be the aim of this publication to show the advantages of the use of cement and concrete for permanent structures, to show the methods and cost of the use of cement in such details that farmers shall be able to decide rationally as to its advantages, and, in general, to encourage and extend its use wherever it seems desirable.

The last report of the Secretary of Agriculure covering the year 1905, alludes to the recent unprecedented prosperity of the American farmer as follows:

"Another year of unsurpassed prosperity to the farmers of this country has been added to the most remarkable series of similar years that has come to the farmers of any country in the annals

*Office of Experiment Stations, U. S. Department of Agriculture.

of the world's agriculture. Production has been unequaled; its value has reached the highest figure yet attained; there is a continuation of the unprecedented savings that have embarrassed local banks with their riches and have troubled farmers to find investments; and, as if all of these manifestations of a high degree of well-being were not enough, the farms themselves have increased in value to a fabulous extent."

The total wealth produced on the farms of the United States in 1905 is estimated at about six and one-half billion dollars. I quote again from the Secretary's report:

"If there is no relapse from this high position that the farmer now holds as a wealth producer, three years hence he may look back over the preceding decade, and, if he will add the annual figures of his wealth production, he will find that the farming element, or about 35 per cent of the population, has produced an amount of wealth within these ten years equal to one-half of the entire National wealth produced by the toil and composed of the surpluses and savings of three centuries."

Throughout the greater portion of the country the pioneer days of hardship and forced economy, which led to temporary and flimsy construction, have passed, and the time has come when the farmer can use the most enduring materials. It seems apparent that the agricultural population needs only to be instructed as to the advantages in the way of adaptability, permanence, and strength, of stone-like materials of construction, among which concrete, plain and reinforced, in most places is by far the most available, to insure their adoption for almost universal use in agricultural construction, putting this country on an equality with the older countries of Europe as to permanance and solidity of such structures.

Residences, barns, ice houses, silos, may be advantageously built entirely of this material, either in the form of concrete blocks, or in monolithic construction, or it may be used only for foundations, for cellar floors, barn floors, feeding troughs and mangers. It will serve for pavements of yards, walks and approaches to buildings where mud is especially likely to accumulate; steps and inclines, hitching posts, fence posts, watering troughs, etc.

Time is lacking to consider all these items, in detail, but perhaps a few general remarks may not be out of place. Where con-

crete is used for floors and pavements in which animals sleep provision must be made for ample bedding in cold weather to counteract the coldness of the pavement. On any pavement for animals the finished surface must be carefully left sufficiently rough that slipping will not be dangerous. For use with water the concrete must be made with special care to secure as impervious a product as possible. In cold climates exposed work must be so made as not to be injured by alternate freezing and thawing.

Water tanks and troughs are perhaps rendered safer from injury if the interior surfaces are given a slant such that ice cannot exert a pressure perpendicular to the surface. In the case of posts, many kinds and shapes with various types of reinforement have been tried, and perhaps much remains to be learned, but this field seems destined to become a very important one and a fortune is awaiting the one who can develop the field by showing how this use may be economically and satisfactorily accomplished.

In these various forms in which concrete is replacing other materials, cost is an essential element. This depends so much upon local conditions, that general statements are difficult. At the eighteenth annual meeting of the Illinois Society of Engineers and Surveyors one of the members stated that a great amount of work on the farm can be built of concrete for less money than when built of wood and cited as an instance a feeding floor.

The manufacture of pipe for use in sewerage and drainage has been widely undertaken and has naturally met with as many difficulties as usually attend efforts in a new direction. But these difficulties have been gradually overcome and there seems to be no doubt that cement pipe can be readily made suitable for these purposes.

In connection with the diversion and use of water in irrigation cement has a wide usefulness; concrete is an admirable material for dams, head works of canals, regulating gates, drops in canals, division gates, bridges over and culverts under canals, canal linings, measuring and division boxes, distribution flumes and pipes, small reservoirs, and reinforced conduits. Some of these structures are in the domain of engineering rather than of agriculture, and our attention for the present will be confined to such features as are related most directly to the farmer.

Cement lining for canals has been used in numerous places

but the first and perhaps the best known case is the Gage Canal at Riverside in Southern California. This canal is about 20 miles long, with a carrying capacity of 37.5 cubic feet per second, and was lined throughout about 1890.

The advantages secured by the use of the cement lining are: a great saving in water from the cutting off of seepage; a great reduction in the number of interruptions to the service of the canal from breaks caused by the work of burrowing animals and by seepage in the fills; a large saving in the cost of annual repairs; and the prevention of the growth of vegetation in the canal with the consequent diminution in its carrying capacity.

Preparatory to putting on the cement surface, all vegetation was removed from the canal, and the bottom and sloping banks were brought carefully to the alignments, slopes and grades determined and fixed by the engineer. Wherever in this process any filling was required it was made of well-tamped clay. As an additional precaution to secure strength and permanence wherever the canal was in fill or where any large part of the banks or bottom was in fill, that part was first covered with a 5 to 6-inch layer of masonry made of good stone laid in cement mortar composed of one part Portland cement, three parts fat lime and twenty parts sand. The surface of the stone work exposed to the water of the canal was plastered with a layer of cement mortar $\frac{3}{8}$-inch thick of one part Portland cement to four parts of sand. Much the greater portion of the bottom and banks of the canal was not protected by stone, but cement plaster of same composition as above, 1 to 4, was laid directly on the clay. The plaster was thoroughly compacted and troweled hard and firm to the alignments and grades and to a thickness of $\frac{3}{4}$-inch finished. An improvement which has been adopted in later work is to form a series of ribs on the back of the cement lining by simply indenting the clay surfaces, before the cement coating is applied, at regular intervals, and in both directions, horizontal and perpendicular, or diagonally. The indentations can readily be made with a "form" while the clay faces are moist, which they should be at the time of the application of the coating.

Repairs on this cemented canal have not been excessive, and fifteen years' experience has amply justified the expenditure and the method used.

The work was done by contract at a cost to the canal company

of about 5 cents per square foot for the portion which was plastered and 13 cents per square foot for the portion with stone-masonry lining. These figures agree closely with the present prices for the same classes of work.

Cement is well adapted to the construction of boxes for the division and measurement of water. At Riverside, Cal., the water is conducted from the Gage Canal through under-ground pipes to concrete measuring boxes on each piece of ground where the water is to be used.

In the distribution of water through the California orchards it is quite customary to use, across one side of each tract, a head flume or pipe from which the water is discharged at as many points as it is desired for the irrigation of the tract. Although lumber has been much used for flumes it is being largely replaced by cement. A machine has been invented for making such flumes in one continuous line in place. The mixture used is one part Portland cement to four of sand. The sand and cement are mixed into a mortar and fed into the machine, which forms the bottom and sides of the flume and compresses the mortar in one operation.

Similar flumes are also made in place by hand tamping in molds in 12-foot sections. These differ from those that are machine-made only in the use of a heavier cross section and a leaner mixture of one part cement to six of sand and gravel.

After a flume is made and before the mortar becomes hard, small tubes from ¾ to 1½ inches in diameter, the size depending somewhat on the size of the flume, are inserted in the side next to the orchard. These tubes may be of tin or galvanized iron, and each has a small slide gate. There should be as many tubes between the rows of trees as there are furrows.

Flumes are made in various widths, depending upon the amount of water to be carried and the grade. Compared with pipe used for the same purpose, as described below, flumes have two disadvantages. They are in the way of surface cultivation, and in orchards they receive the falling leaves which lodge in and clog the orifices. Hence, in orchards, especially, underground pipe is now generally installed in preference to flumes.

Cement flumes are usually constructed by contract at prices about as shown in the following table. The price covers all materials and labor, including the necessary preparation of the ground, and the metal outlets and gates in the side of the flume.

Size—width. Inches	Price per foot Cents.
6	16
8	18
10	20
12	22
14	26

Both cement and salt-glazed vitrified pipes are used in place of earthen head ditches. They are placed below the surface of the ground deep enough not to interfere with plowing, but seldom more than 2 feet beneath the surface, and various contrivances have been designed, some of which are controlled by patents, to distribute the water from them to a large number of furrows in nearly equal and constant streams,

A common practice in citrus orchards is to distribute the water from the cement pipes by means of short stand pipes, of the same material, terminating in circular or semi-circular basins of cement mortar. Each basin has about six holes in the curved portion, through which water is fed to the furrows. The water may be turned on or off by operating a small rubber-faced valve, which is fitted over the top of the standpipe and is flush with the bottom of the basin.

The cement pipe may either be laid in place in a continuous line by a specially designed machine or it may be manufactured in 2-foot lengths, and, after curing, be laid with cement joints.

Different sizes of pipe are used, depending upon the amount of water to be carried and the grade. An 8 or 10-inch pipe will carry from ¾ to 1 cubic foot per second. It is said that an 8-inch pipe will carry 1.5 cubic feet per second on a grade of 1 per cent.

For the manufacture of jointed pipe various types of collapsible sheet metal forms are on the market. A crew of three experienced men can make per day:

500 feet of 8-inch pipe.
400 feet of 10-inch pipe.
350 feet of 12-inch pipe.
320 feet of 16-inch pipe.

A mixture of 1 to 4 or 1 to 5 of Portland cement and coarse sand is used in making pipe. The mixture is used in a rather dry state, in order that the forms may be removed from the pipe at once. In forming the pipe it is important that the material be

well tamped. After standing for 24 hours, or better, 48 hours, the pipes are turned over and the metal rings removed from the ends upon which they have been standing. The pipe must be allowed to set for two weeks to a month before being used. During this time they should be kept damp by being sprinkled two or three times daily, and should be sheltered from the wind and from the direct rays of the sun. As soon as the pipe can be safely handled, their interior surfaces are washed with a mixture of neat cement and lime water to reduce the seepage, which is otherwise considerable while the pipes are new. A man can wash 60 2-foot lengths of 10-inch pipe per hour, using about a pound of cement per length. One barrel of cement will make 80 feet of 8-inch pipe with a mixture of 1 to 5. Cemented joints are made with a mixture of 1 to 3.

Cement pipe is ordinarily considered safe for heads up to 14 feet. Results of scattering tests have been collected as follows: Two lengths of 16-inch pipe, united with a cement joint three weeks old, did not break under a head of 20 feet, or 9 pounds per square inch. A 10-inch pipe broke under a head of 20 feet. An 8-inch pipe did not break under a head of 46 feet, or 20 pounds per square inch. A line one-half mile long of 10-inch pipe, specially made of a 1 to 2 mixture, carries constantly a head of 20 feet.

The following table gives sizes and ordinary contract prices for pipe in Southern California, with the price of cement at about $2.45 per barrel net. The price for pipe laid includes the necessary excavation and covering the pipe after laying. The price not laid for the pipe in the yard where they are made:

Size Inside Diameter	Thickness of Walls		Depth of Bottom of Pipe	Price for continuous pipe, per foot	Price for jointed pipe laid, per foot	Price for jointed pipe, not laid, per foot.
Inches	Inches	Feet	Inches	Cents	Cents	Cents
6	1⅛	2	6	18	16	9
8	1¼	2	8	20	18	12
10	1⅜	2	10	24	22	18
12	1½	3	0	30	28	24
16					45	40
20					60	50

The risers or stands for bringing the water to the surface and discharging it into furrows or portable pipes vary in price

somewhat with the different styles, but in general a simple riser with discharge openings costs about $1.75. A riser with a valve or overflow for regulating the pressure in the pipe line above, in order to maintain a uniform head on the discharge openings, may cost from $3 to $6.

There have been laid in Southern California several hundred miles of cement pipe at a cost of $1,000 to $1,500 per mile.

In a few places large conduits of reinforced concrete have been built for carrying irrigation water, and if these structures prove satisfactory after thorough trial they are destined to come into much more extensive use. At present reinforced concrete seems to be the most available and the cheapest permanent material for closed conduits. It has been used for making inverted siphons to carry water under moderate pressures, but, according to the reports of the United States Reclamation Service, it is almost impossible to make large reinforced concrete conduits to carry successfully a pressure of more than 40 pounds per square inch.

Small circular reservoirs up to 150 feet in diameter made of concrete are in frequent use in connection with irrigation from wells in some parts of the West. An ordinary contract price for such work in California is 20 cents per cubic foot.

An enumeration of the possible lines of use of cement and concrete for agricultural purposes shows the wide adaptability of this material. But the question remains how to secure its widespread use. The farming class is probably the most conservative of any in a community when it comes to trying new materials and processes. The use of cement in any but the most simple ways will always require some amount of special skill and knowledge such that a distinct class of artisans will be required to produce the most satisfactory work. This implies that the cement work in any community must be done by a comparatively small number of men, who will sell their time and knowledge to those for whom the work is to be done. Hence the amount of work that will be done will depend a great deal upon the energy and activity of the cement contractor. It rests very largely with those handling and working with cement to determine how rapidly its use is extended in agricultural lines. Here is a wide field of effort open to those who will aggressively occupy it.

WHAT THE CEMENT USERS OWE TO THE PUBLIC.

R. W. Lesley.*

It is gratifying to be present at the second meeting of the National Association of Cement Users and to realize the great interest that all those who have to do with concrete in its various forms, are taking in this Association.

There are associations of manufacturers of Portland cement; of those interested in concrete, and also for the testing of materials, and it is but fitting and proper that the actual users of cement should get together and join hands in a common movement for the improvement of the character of their work and for good fellowship and business co-operation.

The development of this new art of making concrete in its various forms is one of the remarkable developments of the last decade. The writer, at a meeting of the Engineers' Club and the Board of Trade, at Scranton, Penn., early in 1900, had occasion to look ahead, and in a measure to predict what was going on in this field in this country. At that meeting, speaking of the pliability, the flexibility and the adaptability of the American individuality to the various great purposes which form the industrial and scientific development of our nation, he had occasion to state that the next age succeeding the Age of Steel, would be practically known as the Cement Age, and that it was but philosophical and reasonable that in an age of such great adaptability and plasticity in the individual, that the building material should be of equal plastic character and be represented by concrete, plasters, asphalts or materials of similar characteristics. This prediction, made possibly at random, in this country, was based upon the early development in the art of concrete construction in France, under such experts as Coignet, Bordenave, Hennebique and others, and was looking to the American's idea of quick construction at lowest cost under most unfavorable circumstances, and all these desiderata seemed to be met by the concrete construction which was then being done in a very small way in France. The prediction

*Prest. American Cement Co., Vice-Prest. Assn. for Testing Materials.

has been more than verified, and the proof of it is that in the fifteen years just passed, the production of Portland cement in this country has jumped from 335,500 barrels in 1890 to practically 31,000,000 or 32,000,000 barrels, which is the estimated output for 1905.

Now, we Americans, in our progressive, go-ahead, devil-may-care way, sometimes go too fast, and sometimes take a good many risks, and this business of concrete construction, of concrete block manufacture, of concrete paving and of the many other forms of concrete work, has its dangers as well as its advantages.

The history of the concrete sidewalk business in the Eastern cities is quite an illustration of this important point. When Portland cement was first brought into the United States in any quantity in the years from 1880 to 1890, its principal use was in the construction of sidewalks, and a number of good workmen from the other side and a number of good American workmen instructed by these, engaged in this business. Portland cement was a high-priced commodity. It paid a large duty and the freight was considerable. These early workmen, realizing that they were engaged in a new industry, devoted care, time and skill to the production of the best sidewalk, not a sidewalk that would be as good as brick, stone or slate, but that would be better than any of these sidewalks, relying upon the American desire to pay the highest price for the best article.

These pioneers in the field of cement work went ahead doing work that had no equal. For this work they charged good prices. and upon it made good profits as the reward for their labors. There exist to-day in the cities of New York and Philadelphia, pavements that were laid in the early eighties that have stood the most severe traffic, and that to-day are stronger and less worn than the stone pavements around and about them. In the Broad Street Station, Philadelphia, there is a concrete sidewalk, built with one of the leading brands of German Portland cement, which is laid between the train-shed and the main station building, and to reckon the millions of feet that have passed over, rubbed and scuffed upon this pavement during the twenty years of its existence would be to enumerate many times the population of the United States, and the pavement is as good as when first laid. This is a sample of the old concrete sidewalk work that was done by the pioneers in that industry.

Following these, came others, who, with the natural desire to make more money, to get more work, pursued other paths and sought, by the skimping of material and slighting of work, to produce sidewalks in competition with the older established concerns. The result soon made itself seen. A sidewalk is like the "light" in the Bible, it cannot be hidden under a bushel. It is an everlasting testimony to its own qualities. This class of work scattered all over many of the principal cities and seashore resorts of the East, soon began to disintegrate, to scruff, to spot and to show all the marks of bad workmanship and bad materials. Needless to say that this diversion from the path of right and fairness unsettled the minds of those having to do with the use of concrete sidewalks, and it is a definite recollection of the writer that there was an absolute dead-point reached in the laying of concrete sidewalks in many of the Eastern cities, which endured for several years, and there was very little increase in the laying of these walks, which a few years previously had come to the front as the pavement of the future. The swing of the pendulum came again, and with the advent of American Portland cement, the economy in price caused thereby, the realization on the part of those having to do the work, that only good materials and careful attention to details would produce satisfactory pavements, came a return in the boom of cement sidewalks, which has now spread over our whole country.

In instancing the rise and fall, and again the rise of this particular branch of concrete, the writer does it for the purpose of bringing before you all here the great importance of good work. We are, so far as the manufacture of concrete blocks and production of reinforced concrete buildings is concerned, almost in the exact stage that the cement paving business was when it first began. Many rushed into it, incapable of attention to details, and incapable in the production of good work. Many rushed into it as a new business, hoping to realize quick profits. These naturally, by their lack of attention to details, by the skimping of cement, by the slighting of the work, threw discredit upon the whole industry, and it is the opinion of the writer that just such an Association as that here to-day, formed for the upholding of each other, and by the upholding of each other the upholding of the object of the Association, will bring about results in the field covered by this Association, without that melancholy falling off

that was shown in the early days of the cement sidewalk business. No man, member of this Association, could be, would be or should be guilty of some of the practices that prevailed in the early days of the cement sidewalk.

Only instancing how little is understood of this great art which you are all engaged in, and to show how little those in this country who are always the "all-knowing," namely, the newspapers, actually do know about reinforced concrete, and how possibly from some of these newspaper articles, others might be misled, I will only quote one paragraph from an article in a Buffalo paper describing the fall of a concrete floor in that city.

After describing the method under which the floor was built, the newspaper man interviewed the contractor, and the latter is reported to have said, that "he did not know what caused the collapse, that the floor was of a new type, made to do away with piers, girders or supports."

Now, from such an explanation of a floor in a reputable paper, given by a reputable contractor, others might well imagine that a concrete floor was different from all other floors, inasmuch as it was self-supporting. It might represent an actual investment, or what might be called "floating capital." It might be carried by a balloon, or the sheer strength of this wonderful material we all rely upon, viz, reinforced concrete, might enable the floor to carry itself by some means unknown to the laws of gravitation or nature. If, in this case, the newspaper and the contractor give such explanations as these as to the collapse of a floor, will it be at all surprising, if, in the days to come, uncontrolled by proper specifications, ungoverned by proper requirements as to quality, quantity or character of materials, some daring man will endeavor to build some daring sky-scraper of this material, concrete (which, of all materials, stands the greatest abuse), and build it in some remarkable way whereby some terrible disaster will be caused, throwing discredit not only upon the art of reinforced concrete construction, but upon those engaged in the art and upon the manufacturers of the materials going into the construction. Concrete building construction, as you all know, is very different from concrete pavements. The failure of the latter can only cause very slight injury to person or property.

So, too, with the building block industry. In connection with the Engineering News, the Cement Age joined in offering certain

prizes for the best papers on concrete blocks. The writer was one of three judges, the other two being your honored President, Mr. Richard L. Humphrey, and Professor Edgar Marburg, Secretary of the American Society for Testing Materials—to pass upon the papers submitted to this competition. In considering the papers, it was necessary to look to the art, and it can be safely stated that there was no art. There was no compiled literature, and there was no field of information to be gleaned upon this new and rapidly developed industry. The papers were read with the greatest of interest, and final judgment was passed upon them, and the interesting fact was shown later on, in the criticisms of the various papers by the engineering journals of this country, that these papers, printed in the year 1905, form practically the first permanent literature on this subject, outside of a few scattered and fugitive papers. Is it surprising, therefore, that under these conditions, there have been some mistakes made in the manufacture of concrete blocks? That in some quarters there have been criticisms upon this form of building construction? That there have been questions raised as to whether the blocks should be made wet or dry, and as to how they should be seasoned? When it is considered that this great development in this industry is barely three years old, and the great bulk of it one year old, and that many have gone into it lacking in experience, knowledge and possibly business acumen—the wonder is, on the contrary, that the results have been so good and so successful, and it speaks well for the honesty, straightforwardness and candor of those who have been engaged in the development of this field.

The cement manufacturer has been accused of being in some way a "pullback" in the great development of concrete construction. This is a mistake. He is only conservative in the light of his own experience. He has had his troubles in the introduction of his new material in this country against the well-known and well-established foreign brands; he has had his troubles in building up his reputation, in establishing his works and in introducing new machinery—all incidents of a new industry. He is a little older in this field than you are, but his interests are your interests, and your success is his success. He is tied to you and you are tied to him. Reinforced concrete without cement; concrete blocks without cement, would be Hamlet with Hamlet left out, but in all these forms of construction the first blame of a failure is

usually put on the cement. When all remedies fail, it has to stand the burden. It has nice wide shouders, great amiability and carries the blame like a little gentleman, and while the cement manufacturer, as the pioneer of a new business, looking back during the years of the establishing of his business, realizes possibly, he has been to blame for some of the alleged sins of his material, he feels that he has always been endeavoring to improve the quality of that material which must be beyond suspicion. It is for this reason that possibly he has been a little conservative in connection with all these new methods of concrete construction. His endeavor, so far as his article is concerned, has been to make the best; he formed his association some years before you formed yours, and on the same lines. He realized that the best way to make the best material was to join with the critics of his material and make specifications to govern its production.

The American Society of Civil Engineers had a Committee on the Manipulation of Cement Tests; the American Society for Testing Materials had a Committee on Cement Specifications. At the instance of the latter Society, a joint Committee on the making of Cement Specifications was formed, and to the two Associations above named, were added the Association of American Portland Cement Manufacturers, and American Railway Engineering and Maintenance of Way Association. This committee was at work two years, and finally perfected a specification with which you are all familiar. No people co-operated more toward the work in the forming of that specification than those who were to furnish the material to be judged under the ruling thus made. Submitting himself to the most strenuous tests, the most strenuous requirements that had ever been put in any specification up to that time, the American manufacturer, believing that the best was none too good for the American public, joined hands with his engineering critics, no longer critics, but associates and co-operators in the work, and agreed that his product should meet these stringent requirements. The effect of this has been to give American Portland cement a standing throughout the world.

Following on these lines, those engaged in the construction of reinforced concrete felt that there was danger in this character of work, unless under proper engineering supervision and unless building regulations embodied engineering skill. The danger to life and to property by the construction of these large buildings des-

tined to carry large loads, and to house large bodies of people, was the governing factor in the desire of the constructor of reinforced concrete to have some rules of a permanent character to govern his work.

Following on the lines already referred to in the making of a specification for Portland cement, the American Society of Civil Engineers took the initiative and appointed a Committee on Concrete and Reinforced Concrete. This committee, in accordance with its instructions, affiliated with itself the American Society for Testing Materials, American Railway Engineering and Maintenance of Way Association, and Association of American Portland Cement Manufacturers. It also held meetings with the National Board of Underwriters, National Fire Protection Association, the Concrete Block Machine Manufacturers Association, and the National Association of Cement Users. It is now engaged in carrying on a series of the most exhaustive tests on cement, sand and stone and on the various forms of reinforced concrete construction at the United States Laboratory at St. Louis. It is expected and hoped that out of this serious and careful work there will be formulated such rules, regulations and specifications for reinforced concrete as will, by their simplicity, definiteness and skill warrant their adoption by the Building Departments of all the cities of this country to govern construction in reinforced concrete.

Again the case is shown of the contractor or the producer cooperating with the critic or the agent of the consumer in making specifications which are to rule his product, standards of quality of reinfrocement and of safety which in time will make the construction of the reinforced concrete building as definite and as accurate as the construction of a stone, brick or frame edifice.

Now, having brought before you here to-day what has occurred in the very beginning of the use of Portland cement in the United States; having shown you the swing of the pendulum which nearly destroyed one branch of this business in its infancy; having shown the lack of information and the difficulties that even to-day beset many forms of construction; having called your attention to what the cement manufacturer is doing to raise the standard of his product, to protect his reputation by subjecting his materials to the highest tests; having shown you what the builders of reinforced concrete are doing toward standardizing their method of construction and fixing rules and regulations governing

their business—I want to end this paper by suggesting that this Association, so far as this branch of its business is concerned, shall join with its critics, the engineers and the architects, and shall lend a helping hand toward the standardizing of all forms of reinforced concrete construction and of concrete block construction, so as to insure to the consumer safety, durability and permanence in all construction done by members of this body.

CEMENT BLOCK ARCHITECTURE.

Louis H. Gibson.

I could never have hesitated long in accepting the cement block idea. I have hesitated long, however, in agreeing to accept cement blocks as at present manufactured. I have recognized the inherent merits of concrete construction, and from the beginning have felt that making concrete in block form was a worthy building and commercial enterprise; but as one interested in architectural work, the actual results of concrete manufacture have been such that, until recently I have felt that I could not afford to encourage and foster this industry. I am doing it now in this way, not because of any decided encouragement through specific results, but on account of what I recognize as a possibility. I know that a worthy cement block can be made commercially. My conviction rests upon the well-known and well-recognized merits of concrete as a building material, and because it is desirable to fabricate it into block form. It is difficult to form concrete along proper architectural lines into structural and decorative shapes, such as monolithic walls, columns and lintels. The construction of forms of wood or other material for monolithic structures above grade is very expensive, not readily practical, and by no means satisfactory for structural and decorataive purposes. The block machine is the logical former of concrete for building purposes. Through its agency any shape or form may be made. Concrete will come into structural and decorative use largely through the agency of the machine.

Most of the ancient Greek structures, many of those of the Medieval period, with all of their vitality of expression, their beauty of form, might have been executed with concrete blocks. All that is in the mind and heart of man may be adequately expressed with this building medium. Our highest and best thoughts may be given permanent and adequate expression through the medium of the machine and the concrete. But I have never seen an artistically successful structure executed with cement blocks. I am pinning my faith in concrete blocks

to what I know can be done, and am not resting it upon what I have seen done in a commercial way in a completed structure. I have not seen one worthy, artistic expression through this medium. Think of it as you may, regard these expressions as sentimental, if you will, say that it is all fol-de-rol, if you feel that way, but bear in mind that the cement block industry will rise or fall, you will make money or you will lose it, according as you meet the canons of artistic sentiment. Through the medium of cement blocks you must be able to do what has been done with other building material, give expression to the manifold capacities of the human intellect, with all of its hopes, ambitions and emotional flights, give them permanent form in structural material. Few of you will go into business for art's sake, yet for the dollar's sake you must produce the medium of artistic expression. This you have not done.

There are times when it pays to blurt out the whole truth. This is such a time and this is the truth. Architects are unfriendly to the concrete blocks as now made. Is this because the architect is unfriendly to concrete? I answer this question by asking another. Who has been more ready to use concrete as structural medium than the architect? The architect wants to use the cement blocks. He is always looking for a new medium. The architect will tell you that when you realize the possibilities of this material he is ready to use it.

The most successful terra cotta concern in the world makes the most artistic forms. They carry out the designs of the architect most faithfully. The most prosperous pressed brick makers in America make the most artistic brick. They have certain stock patterns well designed, which a self-respecting architect is not ashamed to use. They will make what he wants, but if he has not time to wait for the new designs, there are often those in stock which he does not hesitate to employ. The architect uses stone, terra cotta, brick, and he uses them in block form; but he is not using concrete in this way. This is the fault of the block maker and not the architect. As now made, he is afraid of it structurally and decoratively, and doubtful of the general capacity of the manufacturer to carry out his plans.

There are those among us who will say that the block maker is not ambitious to furnish material for the great cathedral, the tall office building, the impressive public structure or the modern

palace; that he is willing to let this work go to the quarrymen, the stone cutter or the clayworker. If the concrete block is not for these important buildings it is not for the cottage, it is not for the store, or the factory. Inherently, absolutely there is no relative difference in the structural or ideal of these problems. The fifteen hundred dollar house is deserving of the same quality of attention, the same absolute care as the important structure. The material which will build it well may be a part of the tall office building. The ideal of the man who builds the fifteen hundred dollar house is as high and as worthy as that of him who builds the more important structure. Quality counts for as much with him with his smaller pocket-book as it does to the man with the larger bank account. So far as quality goes, ideals recognize no differences. The brick which goes into the great public buildings is made on the same machine, of the same clay and is the product of the same mind as that which makes the brick for the cottage.

The cement block maker must educate himself to meet the demands of the people, the demands of the architect, the builder, the man who builds the small building or store and those who build the great public structures. The block situation is rather unique. Oftentimes in placing a relatively new product before the people one has to bring the people up to his ideals. One often has to work months and years to secure public attention and appreciation. It is often a long, tiresome road that we have to travel in order to educate the people to the seriousness of our efforts and the excellence of our product. Not so in the case of the cement block worker. The boot is on the other leg. The public is demanding a structurally better product, a substance more highly developed artistically than you are giving them. The opportunity is a rare one. It is for you to educate yourselves to meet the public standard. A greater opportunity never presented itself to a lot of business men.

Do not imagine for a minute that art needs help from you. It is you who need the help of art, and the foundation of your art is utility. You are not to be patrons of the arts for art's sake. You are patrons of art for your own sake, for your pocket books' sake. You need art; art does not need you.

A very large measure of the growth in civilization expresses itself through the application of art to industrial enter-

prises. I wonder if we realize the relation of art to industry, the relation of art to trade, the relation of art to commerce. The walls and roofs of our houses are something more than mere protection. The porch is something more than mere shade. Our clothing is something more than mere covering. A chair is something more than a place to sit. A door has long since ceased to be only a protection from the elements or the enemy. It is something more. That more is art. There is a limit to strictly physical needs and capacities, but there is no conceivable limit to our aesthetic needs and capacities. It is not our physical demands which make great value. On the contrary, it is our ideals, the expression of our emotion through material means. It is meeting our aesthetic demands which give great value to raw material. The modern alchemists are the artist, the scientist, the engineer,—men who have ideals and give them practical expression. The modern alchemist mixes the sand, the cement, gives it form and turns it into gold. This is the key to the cement block situation today.

The modern alchemist who would turn sand and cement into gold must first learn how to make concrete. Block makers and cement workers generally are lamentably ignorant in this fundamental operation. The impression has gotten out that a laborer who is not fit for anything else can mix concrete, that the cheapest labor that one can employ is good enough to do this work. This part of the world is well saturated with this idea. The question of brains and the concrete mixer is rarely considered. The real trouble, the great trouble, almost the only difficulty in the physical composition of cement blocks is in the making of concrete. With this understood and appreciated, thoroughly ingrained into the cement worker, his physical difficulties are well out of the way. This must be done before he can hope to succeed through any other means. What good is the artistic block, the well-formed block, what good is the business organization, what good is it to lay out working plans for the setting of the blocks if the primary work, the concrete making, be not properly done? The block maker, strange as it may appear, is the most difficult of all men to interest in the mixing of concrete. The architect who talks to the block maker is apt to meet a dull ear on this question. His auditor thinks that it is the other fellow. He will acknowledge that the rest of the regiment is out of step on

concrete making, but that he is the man who is in step. The makers of cement blocks in a commercial way almost to a man are indifferent concrete makers, so far as I know them.

As one travels over the country he can see in the ugly blocks the primary cause of the physical trouble. Before we get through with our block business we are going to grade our sand; we shall know that the voids are reduced to a minimum before the cement is introduced, and we shall thoroughly mix the sand and the cement in the dryer before the water is applied. Most cement workers believe that they are already doing this. Their wrong belief is the source of the physical trouble. It is the cock-sureness of nearly all that is the real stumbling block. Block makers particularly have been educated by the machine salesman that any old thing can mix concrete. This thought has been suggested so often, so long that the improper mixing of concrete, the careless, indifferent mixing has become a habit, almost a fixed state of mind. It will come to the point in the block business where we will employ mechanical sand graders, dryers and mixers. However, it may be done, the result must be a relative filling of the voids before the cement is introduced. Whenever we can get ourselves into that state of mind where we may realize that we have not been doing this, where we can realize that we have been spoiling a lot of good cement in a primary process, whenever we can get rid of our cock-sureness our egotism on concrete mixing, then we are in a fair way out of our troubles of a physical character. When we learn to mix concrete we can hope to make the impervious block. Cement makers, as a class, have done their work well and scientifically. They have availed themselves of all of the resources of science, and it appears absurd that this work should have stopped with the making of the cement. The chemist, the engineer and the cement maker have joined hands in the making of cement. In the making of blocks they have parted company. The situation is ridiculous. We have been floundering around doping our blocks or letting the rain pour through them, merely because we have not given the right kind of attention to a primary step in block making. This grading of sand, the mixing of sand and cement, the general question of concrete making is being seriously considered by eminent engineers They are demonstrating their thought. It is being recorded in text books. Whenever we get rid of the idea that any vagabond can

mix concrete we are in a fair way to advance. Then we shall invoke the aid of the scientist and become modern alchemists.

We may take lessons from the modern mechanical mortar maker in the mixing of the aggregate in concrete. He dries his sand and mixes it mechanically. The makers of Bitulithic pavement have reduced the grading process to a science, and on that account are reaching a large measure of success. We may study a modern asphalt plant with profit. We need not expect to absolutely transfer their methods any more than we can expect to buy a clay brick machine and mold cement brick with it. We will show our quality by our faculty of adaptation. I say again for the sake of emphasis that the key to the situation in concrete mixing to reduce the voids to the lowest possible terms, before introducing the cement. Until we have done this we can have no arbitrary standard for the proportion of cement. We must get ino the concrete business before we can get into the block business. If we could realize this we would soon be out of our troubles.

Sand must be clean. Most cement blocks that I know anything about are made of dirty sand. Very little thought has been given to getting it clean. A block maker said recently, "I wonder how it is that my blocks are not of a uniform color. I use the same sand and the same cement and the same proportion all the time. It was not necessary to go to the pit to determine the cause. Just then a team with a wagon load of sand drove up, and on top there were clods of earth which had rolled down from the soil covering of the sand bed. Of course this soil was more or less mixed with sand. Necessarily the blocks were more or less affected by it. All of them were of a muddy tone. If one would make a clear, crisp, live colored block he must use clean, crisp, sharp, lively sand. Barnyard mixtures make barnyard colors. Most of the blocks that we see are dull, heavy, lifeless, and leaden in color and texture. This can be obviated by clean sand and a proper proportion of cement of the right kind. The Oolitic stone that we use in our best buildings is almost absolutely pure in its ingredients; that is, there is practically nothing in it that does not organically belong to the stone. This is true of sand stone, marble and granite that are used for building purposes. The ingredients are relatively pure. If not, the stone

is not marketed for high grade building purposes. There have been statements made through various scientific sources that a certain small proportion of clay or loam does not affect the integrity of concrete, This may or may not be true with respect to the general strength of the mixture. The authorities who have made this statement are not taking into consideration the question of color and texture. They are estimating it from the standpoint of strength, not color. While I believe that if the sand were properly graded from the finest to the coarsest it would be better without the clay or loam, that is neither here nor there with respect to cement blocks that are exposed to view where texture and color are important. As we ride through the country and see the cement block buildings with their dull, leaden color, we may trace it to dirty sand.

We may do whatever we please with cement mixtures with respect to color and texture. We may make a white block if we will, but we must use white sand and white cement and must handle it with clean hands and clean tools. A few years ago in Havana I lived in a house which had a monolithic cement floor with a cement border in three colors and a cement center piece with more than three colors. The design was beautiful as it was intricate. The texture was pleasing. The colors were just what the artist intended they should be. When he wished them to be quiet and subdued he had properly mixed the ingredients for that result; when decided and sharp, he had achieved that result. Such floors are very common in the Latin countries.

We shall mix our aggregate with more water than has been common with most of us. We shall then experience troubles from crazing, and hair cracking if we do not take advantage of our opportunities. The cause of this trouble from cracking suggests its own remedy. It is the relatively neat cement on the outside of the block, the difference between the composition of the surface of the block and the interior—a difference in contraction. If our blocks are of the right composition we may wash them with a brush and cover them with damp cloth while they are setting. We may rake them over with a fine toothed tool. We may give them a texture with a wire brush. The man of resource, keen perception and artistic insight will find many ways of getting around this difficulty. With blocks which are merely structural and are not intended to look well he will not

disturb himself with this work, as the crazing does not affect the physical integrity of the block.

The principle involving the production of proper texture is not difficult to understand when we analyze it. We want cement enough and certainly not too much. We know that we want it evenly distributed. The nearer we can come to exposing the sand on the surface, the nearer we can come to having the view side of the sand, the side that we see, free from cement, the better. Those of us who can remember the lost art of old fashioned hard finshed wall plaster know what this means. With a brush and water the plasterer washed out all superfluous lime and up to a certain point the more lime he washed out, the harder and stronger, brighter and crisper he got his plastering. This principle may be applied to the surfacing of cement blocks. In one way or another we shall wash out the neat cement.

Unless the proportion of sand and cement be uniform, the texture will not be uniform. The best brick that are now made for decorative purposes, for facing are not intensely smooth. They have a grain, a texture, we call it. The surface is gritty. It has somewhat of a sand paper quality. It receives the light in a pleasing way. This is what we mean when we say that a surface of stone or brick has good texture. The stone with the rubbed surface, with the paste of the rubbed stone left in it, has not the pleasing texture of the tooled surface or even of the surface after it has been carefully washed and sponged. The pasty surface of the stone is in a measure allied to the neat cement surface of the cement block. When we get rid of this, by whatever means, we get texture, and texture we must have in the cement block in order to meet the demands of the man with a pocketbook. He does not have to buy the cement block. He may buy brick or stone or terra cotta, and he will buy these materials unless you give him a better block than he has been getting.

I have merely hinted at the possibilities of color work in concrete. We have not yet reached the stage where it would be very profitable to go into this. When we know how to mix sand and use clean materials and mix the cement and water with it, when we know how to handle our blocks, when we know texture and uniformity, then may we consider color. It is sufficient to say that the liveliest imagination of the Arabian and the

people of the Orient may find permanent record and adequate expression in the color, texture and substance of the cement block. We will have to get out of the back yard and shed stage of this industry, however, before we can take up cement polychrome.

The immediate task before us is to do the best with what we have with the men and the brains that we have, with the sand and the cement that we have. The cement is adequate to our ability for some time to come. We can afford to disturb ourselves a whole lot less about cement and a whole lot more about sand. As soon as we give the sand question more attention we shall discover that we have no absolutely arbitrary standard of proportion and that we shall get along and get better result with less cement than before. The nearer we can come to filling the voids with sand within reasonable limits the less cement we shall use. The proportion of cement is a determinable quantity. In order to secure texture we shall use as little cement as possible at the same time that we secure strength and integrity of block. The less cement we have within reasonable limits, the better texture we get, and as we all know, enough cement in the composition of the block, is all we want. We know that a surplus is a detriment.

An influential cause for the ill feeling which architects have for the cement block is the difficulty of having their plans exactly carried out. There is too much cut-and-try business. It is only recently that the writer met a prominent architect who was expressing himself in fierce terms because he could not get his windows placed exactly in the vertical and horizontal position that he wished without having the work taken down more than once and then submitting to a series of compromises. The architect or the builder is not going to submit to compromises in one material that he does not have to submit to in others. In terra cotta, stone and brick all plans can be carried out to a nicety; and there are no advantages otherwise in the concrete block which will lead to a compromise in its favor. The setting plans of a stone cutter and a terra cotta worker are marvels of neatness, exactness and accuracy. Great buildings are built practically without the sound of a hammer. Certainly the work is fitted before it leaves the cutting shop or the factory. There is no reason why this should not be done in the same way by

the block maker. It must be done or the block business will not succeed. I recently had an experience with a block maker who made a setting plan on a shingle and then lost the shingle.

From the standpoint of the machine, the cement industry is in good shape. The business has been fostered and promoted very largely by machine makers. However, the industry has been injured by the machine salesman who has minimized and at times concealed the difficulties in the way of making a commercial block. So far as the block is concerned the machine is the least important factor in its manufacture. A cement block can be made in a wooden box. Any machine will make a block that is commercially satisfactory if the material is at hand to put into it, providing there is an opportunity for proper tamping or compression. The important part which the machine plays in this industry is in reducing the cost of the block. This work has been well done and little need be said about it here. It is well for the block maker to understand, however, that he must be able to so adjust his machine that a block any size in any direction within fractions of an inch can be readily made on a commercial basis. The builder, the house owner, the investor can get what he wants in other materials and he will not put up with compromises in the block.

The laying out of the work in the shop and the preparation of careful shop drawings will very largely eliminate the evil of indifferent handicraft, bad workmanship, and we all know that there is no branch of the building business that has suffered as much at the hands of the botch as the block industry. The block maker will have to see to it not only that his work is properly executed and properly shaped in his factory, but that it is properly laid up. The stone setter, as capable as he may be, and the brick layer, as intelligent as many of them are, are each prejudiced in favor of his own work and his own material, and are certainly not friendly to a relatively new substance. The work must be properly laid out, properly related to other materials properly set, cleaned and pointed. The cement block needs friends. The metal worker gets out his material with exquisite care, prepares elaborate drawings and brings them to the building along with the stone setter, the terra cotta worker and other mechanics. He expects others who furnish build-

ing materials to exactly meet his work in order that he may meet theirs. It is a question of mutual respect. The cement block maker is entitled to the respect of other mechanics and workers when he gets out his product in the same systematic and orderly manner as his associates. He must do this in order to get the business—to get the dollar.

The cement block industry in order to be successful must be capable of producing a material which will realize a building as beautiful as that which can be constructed in any other material. Concrete in its nature suggests a comparison with stone. Hence, the high standard. A part of beauty in a building is color, texture, general design, but after that there comes the question of detail, of parts, the moldings, the ornament. On the one hand there is mere construction, mere building, and then there is art. In order to have architecture there must be both building and art. In architecture the two are inseparable. It costs no more money to make a beautiful form than it does an ugly one. I would regard it as an opportunity lost if I did not say here and now in the strongest terms at my command that there is *no excuse for an ugly structure of any kind in this world.* Be it a building, a bridge, a bit of furniture, a machine or any other object in which material and labor are brought together there is absolutely no excuse for ugliness on any account. There is no excuse for ugliness on the grounds of cost. Good proportion costs no more than bad proportion, harmony of color cost no more than inharmony, there is no more expense of material or labor in a well formed molding than in an ugly one. There is no more expense attached to grace than to clumsiness. Beauty is a condition of mind, a condition of heart, of character, and not one of pocketbook. Clumsiness and crudeness come out of a crude and clumsy mind. It takes no more time or material and no more labor to cast a beautifully formed block than one ugly in form. It takes no more time or material to cast a beautiful piece of ornament than one which is crude and clumsy. I do not say that one form may not be more expensive to cast than another, but I do say that there is no excuse for casting an ugly one, and that the question of beauty or ugliness need cut no figure in the question of cost. Everything made by man might be beautiful without material consideration. Beauty is first a state of mind. You wish to make certain beautiful

forms for ornamental and decorative purposes so that when people come to buy you have something to show them, so that when they have built, the houses will be more than commonly beautiful, and other houses of cement block will be built and you will get the money therefor. There are certain standard forms that can be produced and reproduced as they have been for more than twenty-five hundred years. Their repetition has had no effect upon their beauty or appreciation by the public. The forms most commonly in use at this time by architects, artists and builders date from the 15th and 16th centuries. It is from this source that the ornamental brick makers draw most of their inspiration. It will be necessary for you to employ artistic designers who can design for you certain relatively simple standard designs which may be readily adaptable for various purposes. This is an eminently practical thing to do, and it must and will be done if the block business reaches any large measure of commercial success. Hitherto, the block maker has been a great sinner in producing crude and ugly shapes. This is absolutely without excuse.

The cement block machine may be a great art democrat. It may produce and reproduce artistic forms for the masses. It may give us beautifully decorated structures at a minimum of cost. Art is not for the few any more than education is for the few. Art should be democratic, and the block machine should be a great art democrat. There is an intimate relation between this idea and the bank account of the block maker.

There are those among you who will say that these expressions in regard to the making of concrete, the grading of sand, the cleaning or washing of sand, the fine adjustment of mixtures, the matter relating to color, form and art are ideal. Possibly they are ideal. I hope so. We progress through idealization. We express our civilization, our ideals, through material and labor. The wigwam is the idealization of a dug-out hole in the ground. The cottage is a man's materialization of a state of mind which seeks something more than to keep out of the wet

and cold. But for idealization we would not quarry or cut stone. We would not make brick. The face brick period is expressive of higher ideals than the rough, mud brick period. The truth of the whole business is that the concrete block industry has not reached the stage where it produces a material through which the people care to express their highest ideals. If our blocks are not good enough to materialize a high ideal in a cathedral, a public building, a house intended for a home, they are not good enough for anything above the ground.

WATERPROOFING.

J. L. Mothershead, Jr.

The waterproofing of concrete blocks is a subject of the greatest importance to all who are in any way interested in the manufacture of this building material. I think it may safely be said that the life of the whole industry depends on it

Common clay bricks are not waterproof but the public has become so accustomed to their use and to their disadvantages that in getting something to take their place we must have an article which has all of their advantages and none of their disadvantages; consequently we must build dry houses with concrete blocks and without furring or the public will soon stop using the blocks.

When an error is discovered in a business house an immediate search for the culprit is pursued and when he is found he is called to account. I propose that we follow this course now. The first culprit is the manufacturer of machines who sells one to a lawyer, doctor or some other such experienced worker in cement and then leaves him to work out his own salvation. These manufacturers have fortunately seen the error of their ways and have organized an association which will overcome them. All of us most certainly wish them every success in the good work.

Then we come to the block manufacturer who believes that any Tom, Dick or Harry can make good blocks, and that all he needs is some dirty sand and a little cement. He sells a few blocks because they look all right and that is the only test that the customer knows how to apply. As the blocks are poor they give rise to constant trouble and during the rainy season the water goes through the walls in which they are placed as it would through a sieve.

But the man who injures the industry the most, is the one who buys a machine and goes to making his own blocks on his building site, using poor material, without proper mixing, and

then as time is an item he puts the blocks into the wall without any curing. My attention was attracted to a cement house in Indianapolis which was built in this manner. The blocks were so poorly made that with a small stick you could dig holes in them. I reported it to the building inspector but he seemed unable to do anything, and so the house stands today as an example of concrete block construction.

However, what is one man's difficulty is another's opportunity, and so there are a number of preparations on the market for waterproofing blocks. I will endeavor to speak of the various methods of making blocks waterproof:

First, Make good blocks. We have before us the question of making them correctly. It is impossible to attempt waterproof houses unless the blocks are well made and well cured. Too much can not be said on this point, and our only hope is that the quality of the average block will improve as the industry grows older. That is the first thing to strive for; honest material made into blocks in an honest manner and well cured. This alone will not produce waterproof blocks but we must have it as a foundation or any special design or use of chemicals will fail.

Second, comes the use of richer material as a facing for the blocks. All reasoning tends to condemn this method as there will be two rates of contraction and expansion in the same block and the natural result will be a splitting apart of the two mixtures. Some manufacturers claim that by making the blocks face down the danger of the occurrence is removed. Perhaps it is and perhaps it is not, experience alone will show, but one fact must be considered and that is that when a block is made face down the forces exerted in the manufacture of it are at right angles to the direction in which the force is applied when the block is in the wall. This seems like a waste of opportunity for making a strong building.

I was walking around the yard of a well known block manufacturer and we were talking about faced blocks. During the discussion we examined some blocks which had been made in this manner, three years ago, and found cracks between the facing and the remainder of the block. This man is a progressive, conscientious block maker and I have every confidence in the blocks which he turns out, and consequently our discovery somewhat shattered my faith in faced blocks.

Third. We have the two piece system. In this class we put all blocks in which there is no direct concrete partition between the inner and the outer wall. I can see no reason why this system should not be perfectly satisfactory as regards making a dry house. Whether they are strong enough and easy of construction, etc., is a matter outside of my province.

Fourth. I want to consider the addition of chemicals to the concrete in the course of manufacture. About a year ago, I experimented extensively in adding various mixtures of chemicals to cement and making briquettes and testing them for strength. Some chemicals of course were very injurious and some highly advantageous.

It has always been my theory that the ideal of waterproofing concrete was by adding a chemical during the mixing of the sand and cement and my work was along that line. I may at this point state that I discovered a material which when mixed with concrete had wonderful effect on it. The blocks containing this chemical were white in appearance, absorbed about one-half per cent of water, and were of increased strength and density. I did not put this on the market as it increased the cost of a block a couple of cents and my observation of the trade has been that it is after quick returns and the manufacturer does not care for anything which reduces his immediate profit no matter how large his future returns may be.

I also experimented on the addition of various salts to cement and found that they did not decrease the porosity to any noticeable extent, so they were of no use to me in waterproofing. I did, however, find that they shortened the time of setting to such an extent that the results of strength tests after 48 hours showed sometimes as high as 100 per cent increased strength. Also they allowed the use of cement in temperatures several degrees below freezing.

Such salts as chloride of barium and chloride of sodium (common salt) were the best for this purpose.

One of my experiments showed after 48 hours:

Common cement	90 pounds.
Chloride of calcium	167 pounds.
Chloride of magnesia	55 pounds.
Chloride of barium	232 pounds.

The addition of these ingredients however, increased greatly the efflorescence as they are water soluble and the discoloration of cement is caused by water soaking in the blocks and then coming to the surface to deposit the salts after the evaporation of the water.

This of course is a great disadvantage and should be carefully guarded against by the block manufacturer in buying preparations of secret composition.

I also would like to touch on the use of lime in mixing the blocks. The practice is becoming quite general and I believe largely through ignorance on the part of the manufacturers. You all know that lime in the usual form is detrimental to the strength of the block but a great many believe that the hydrated form is safe to use. This is a mistake and should be carefully guarded against. I read an article in one of the magazines devoted to cement, recommending the use of hydrated lime for waterproofing and was very much surprised to find such ignorance on the part of the editor. The hydrated lime when used in the blocks is attacked by the carbonic acid in the air and changed to carbonate of lime which has a tendency to disintegrate the blocks and deposit a white stain on the outside. Lime does undoubtedly whiten the blocks and make a better looking article but no experienced maker will use it if he wishes to firmly establish his business.

The first quick success of the block business will be its death stroke if we are not careful for the manufacturer has flooded the market with a lot of cheap poor blocks and the cry seems to be: "After us the deluge." But it won't be after us but on us.

THE CAUSES OF FAILURE IN THE CONCRETE BLOCK BUSINESS.

O. U. Miracle.

It certainly would be presumptive on my part to assume to tell you all the causes of failure or lack of success in the concrete block industry. Many theories may be found inefficient when put to practical tests, so I shall only treat the subject in the light of my own observations in the field, and shall point out the most glaring dangers which seem to confront us, in order that we may suggest remedies to overcome them.

It has been readily acknowledged on every hand that this great new industry has taken on a most wonderful and surprising growth, in fact its strides have far out-reached the fondest hopes of its most ardent advocates. In such a rapid growth, there are bound to be some new points developed and it is certainly well for us to pause at this time to examine the structures we have reared and see if there is any occasion for repairs, or weak points which we may overcome in future work.

That there have been some failures in this business, we must at once admit and it is certainly well for us to view these failures in the glaring limelight of publicity and ascertain if possible the causes in order that the proper remedies may be applied. Some one has said: "It is better to be sure than to be sorry." This is certainly an excellent motto for the concrete block manufacturer. While the financial failures in the business have been comparatively few, the moral failures in the end have been many.

So long as man is human, it will be out of the question to wholly eliminate the moral failures. So long as building material is made and used, there will be differences in the qualities produced, but by the application of the principles and facts already evolved, we can certainly very materially increase the percentage of failures and not only increase the percentage of successes by this gain, but by correspondingly improving the quality and utility of this material, greatly add to the profits of the business.

In looking over the field I find that these failures are due to a great variety of causes. Right here I want to again remind the manufacturers of concrete machinery of the grave responsibility of the position which they occupy in this matter. The field has proven such an interesting one that it has attracted investments by men in all walks of life. Many have engaged in this business whose fund of knowledge on the subject was of necessity limited. They have largely depended for their information upon the literature put out by the various machinery manufacturers. This information has in many cases, either through ignorance of the subject, or a desire to make the proposition look more attractive than it really was, been very misleading, and the instructions given, if followed, would in many cases result in dire disaster. True, this was a new field and we all had much to learn about it, but now that we have progressed far enough into the subject to ascertain certain indisputable facts that there is no way of getting away from, I most earnestly urge that the machinery manufacturer, in preparing his literature, confine himself to these facts.

Even in the past few weeks I have seen literature in circulation from what I considered reputable concerns, advertising certain cement block and brick machines, which gave the estimated cost of the manufactured product, at less than the cement alone required to produce a good article, would cost. These figures ran too ridiculously low to be worthy of consideration or repetition and indicate mixtures varying from one to six to one to nine which are far too lean. While on the other hand, a gentleman who claimed to have twenty years' experience in contracting and the use of cement, told me the other day, that he had about made up his mind to buy a certain type of machine because the manufacturer told him it pressed the blocks so hard that they could be laid in the wall the next day after making. Now with such information as this being dealt out at wholesale by men who are supposed to know what they are talking about, isn't it about time for us to start a little more extensive campaign of education? Isn't it time the public knew more about this great subject? These rash statements often come from the overzealous salesman, but altogether too often from the machinery manufacturer himself. Their claims of results are often too far out of reason to be reached under even ideal conditions. Gentle-

men, I want to urge upon you who are in the machinery manufacturing business that for the sake of the stability and integrity of this great industry, it is important that we unite in doing away with this great evil. Get down to facts and stay there. We are all human and capable of errors, but now that we know better, let's not commit these same errors over again.

In almost all estimates of cost of manufacture, I find that account has been taken only of the direct expense, no mention whatever, is made of indirect expense, such as advertising, superintendence, interest on the investment, depreciation, loss from breakage, bad accounts, etc. This is by no means, "a get-rich-quick" scheme, but one of the best paying and most legitimate propositions before the investing public today, notwithstanding the fact that some of the literature in circulation is painfully strong in having that "get-rich-quick" ring to it. There is sufficient profit in the business to place it on a much higher plane than has been aimed at by many manufacturers. The facts of the matter are, including all the extra items of expense, there is still more chance for gain in this business than in the manufacture or production of any other building material of equal strength and lasting qualities. Up to the present time we have been very lame in the lack of standard specifications for the manufacture of this product. In order to get this matter on a uniform basis, it was brought up at the meeting of the cement block manufacturers, held in Chicago last June, and as chairman of a committee appointed for this purpose, I hope to have the pleasure of submitting a progress report, at an early date, and the same will be given due publicity.

While we are on this part of the subject, it may be well to call attention to the fact, that the machinery manufacturers are not alone to blame for the placing upon the market of poor material. Many who have engaged in this business have made very serious mistakes—mistakes which are expensive, but which can be overcome. Within the past week a case has been brought to my notice, where the party failed absolutely, and his machinery, plant, stock, etc., are now in the hands of the Sheriff. This man made serious mistakes and many of them. In the first place he did not attempt to secure any business on merit; he had the idea that he must always be below his competitors to get orders. If the other fellow's figures on a certain job were five hundred or

a thousand dollars, he would invariably bid 10 to 25 per cent. lower on the jobs he secured.

Under these conditions, what could you expect but inferior material and poor workmanship—in the end a botch job, and worst of all a dissatisfied customer, who uses his influence against cement work at every opportunity.

It therefore comes to us most forcibly, that you who are furnishing this product to the public, must get together on a basis that will insure a uniform product of no uncertain quality, and it will then command the price of which it is worthy. So much for the moral failures.

Then we have the man who goes into business with insufficient capital. Some manufacturer has sold him a machine or partial equipment, simply because he had the price, or a part of it; he gets credit of his local dealer to the extent of the price of a few barrels of cement at a good round price. He makes a few blocks and sells them while they are yet too green for use, in order to get funds for his pressing needs. He discovers on account of his men being new to the business, or for some other reason, that the blocks cost him much more than he anticipated, or twice as much as the over anxious salesmen told him they would. He is short on profits and has already established a selling price at too low a figure. The tendency then is to attempt to make a profit at the already established price by cutting down the amount of cement used and correspondingly increasing the amount of sand. The results are too well known—he is down and out in a short time—condemns the business in general, and the machine in particular that he bought and is not slow to discourage others. By the time the report of his failure gets into about the third or fourth hands, the conditions responsible for the results are lost sight of, and the report is spread broad-cast, that the business is a fizzle.

Next we come to the architect. He occupies a very important relative position in this matter, and his adverse criticism, has no doubt proved a stumbling block to many of you. The value of his opinion and endorsement have been too lightly estimated by many. His position has of necessity been one of great care and caution. He is not willing to depart from fields of well-known practice for the mere novelty of an experiment. His position must be secure—in other words—"he is from Mis-

souri and has to be shown," but he has been a very careful student of the concrete block, and where a year or two years ago he turned a deaf ear to the proposition, he has discovered now that the material is already established, and he is willing to consider it for his requirements. But it must fill them. His first, and most important objection is, lack of quality. Assure him of this and he is ready to make a beginning. But he is immediately confronted with the question of appearance and utility. His objection as to appearance is certainly justified by certain glaring examples. It is lamentable that a material so easily susceptible to artistic designs, has been so shamefully treated. Each of you can bring to your mind a building of concrete blocks, every one of which is of exactly the same size, and style of rock face design, with no sign of an attempt of ornamentation. There is no legitimate excuse for this neglect, and do you think it is any wonder that Mr. Architect finds fault with the appearance of this kind of a building?—certainly not. He can get the same effect in appearance with the cheapest kind of boards covered with still cheaper stamped sheet iron. He wants more variety of design, and if you will set about it, there is nothing easier than for you to give it to him. True, additional design means added expense, but you will be placing the business on a higher plane, and your profits will increase correspondingly.

I have visited many yards where the owners were making less than half the designs and sizes of block their outfit was capable of turning out. While it is true, there has been a demand for this rock face block, which you all make, I hope the time will soon come when you will get away from this idea entirely. It is at best but an imitation. As I have said on other occasions, I believe that this material is entitled to a distinct classification of its own, and a building made of it, should be designated as a concrete building, and not as artificial stone, as so many call it.

One of the handsomest buildings I have ever seen of concrete was made of all plain face blocks for the body of the building, with bevel coigns at the corners and openings, with a few ornamental designs utilized as belt course and cornice.

Another just objection of the architect, is the extreme porosity or lack of permeability of many blocks. This com-

bined with the strength of the material, is the all important part of this proposition, and these objections are being rapidly overcome. This comes properly under the subject of manufacture and specification, and I shall only touch lightly upon it, as so important a subject is worthy of more lengthy consideration. The results obtained in this direction depend upon the following five vital points:

1st—Proper selection and proportioning of materials.

2nd—Careful mixing and complete incorporation of the ingredients.

3rd—Careful and thorough tamping.

4th—Care in curing.

5th—Care in laying.

PROPER SELECTION AND PROPORTIONING OF MATERIALS.

Under this subject naturally come the selection of the cement, sand and aggregates. The cement should in all cases be a first class Portland guaranteed to stand the tests required by the specifictions for Portland cement, adopted by the American Society for Testing Materials. In the selection of sand and aggregates, the greatest care should also be exercised. I maintain that sand should be practically free from clay, loam or other soluble matters; notwithstanding the fact that many tests have shown that a small proportion of clay is not harmful. I believe it to be a very dangerous practice to recommend the use of sand containing any perceptible amount of clay, from the fact that the average worker has no facilities for determining the percentage found in his material. If possible the sand should be graded in sizes, so as to reduce the voids to the smallest possible amount. The percentage of cement used with the sand should be such as to perfectly fill these voids. For determining the voids, the water test may be employed without laboratory facilites.

Average sand is found to contain 25 to 35 per cent voids, indicating the necessity of using this percentage of cement to make a perfect sand cement mortar.

Where aggregates are employed, the voids in the aggregates may be determined in the same manner as they are in the sand, and an amount of the sand and cement mixture equal to the amount of voids in the aggregate, should be used to make a perfect stone.

CAREFUL MILLING AND COMPLETE INCORPORATION OF THE INGREDIENTS.

Machine mixing is at all times preferable and invariably produces a better concrete by at least 10 to 15 per cent, than can be made by hand mixing. The materials should be thoroughly incorporated and mixed, until of uniform color.

When an aggregate is used, the sand and cement should be well mixed first, then the aggregates and water may be added at the same time.

I believe that with any of the machines now on the market, a much wetter mixture can be used than is generally employed if proper care is taken of the face plates. The face plates should be kept clean with a wire brush, and be given a coat of oil or shellac as frequently as once a day.

CAREFUL AND THOROUGH TAMPING.

The tamping should commence with the placing of the first shovel full of material in the mold, and should continue until the mold box is full. A small face tamper should be used, and quick, sharp blows should be struck.

Many unsightly buildings have been put up of blocks which showed uneveness in their texture, on account of careless and uneven tamping.

CARE IN CURING.

No part of the manufacture of concrete blocks is more important than the curing, and I regret to say that this essential part of the manufacture is altogether too frequently disregarded.

Blocks should be kept moist for at least seven days after making. The water should be applied with a spray or sprinkler immediately after the initial set has taken place, or as soon as it can be applied without washing the stone.

Another fault that I have discovered in this connection, is the fact that many yards do not carry sufficient stocks of blocks on hand—they wait until they have secured the contract before making the stone, and they are in this case rushed into the building, too green, and bad results will inevitably follow.

No concrete stone made in the manner above described, should be laid in the wall, until it is at least 30 days of age.

Green blocks should never be exposed to the rays of the sun or warm currents of air, during the first seven days when they are supposed to be kept moist.

I have seen in the early stages of this business, blocks made under an open shed, immediately placed out on a hill side, exposed to the sun and wind, with no water applied, except such as was pumped with a common wooden pump and carried in buckets, and you all know too well the results that come from this careless hap-hazard method.

Is it any wonder that blocks made in this manner are porous, or that they absorb moisture readily?

Many of you have seen buildings of concrete blocks, which showed bad cracks in the wall. A building of this material requires just as solid a foundation as though built of any other substance, but in nine cases out of ten, where I have found cracked buildings, I have found this result came from laying the blocks in the wall too green. They must have at least 30 days in which to cure, and they are better if they are 60 days or even 6 months old.

CARE IN LAYING.

Too great stress cannot be put upon this important part of the business. A mortar of equal parts of lime and cement to 2 and 3 parts of sand, should be used, and all blocks carefully bedded and butted on the ends, and the joints well pointed up. This pointing should be done at the time of the laying, as if done at some later period, the blocks are apt to absorb the moisture from the mortar, thereby loosening it, so that it will drop out.

Some blocks are provided with small oval openings at the ends for the reception of a soft cement mortar. After a course of this style blocks has been laid in a wall, the mason should go along the wall with a measure of mortar, sufficiently plastic, to pour into these oval openings. This not only insures a tight joint, but acts as a dowel to tie the wall.

I have seen many jobs completed, which were very unsightly on account of the carelessness of the mason in allowing the blocks to become spattered with the mortar. This can easily be avoided, and I have found it in most cases comes from masons who are prejudiced against the use of concrete blocks.

These subjects will be more carefully discussed in the report

of the committee upon Standard Specifications for Concrete Blocks, which was appointed by the cement block machine manufacturers, as above referred to.

Summing up, we find that we have arrived at a very vital and important point in the progress and development of this business—we have arrived at the "Parting of the Ways."

There will be two distinct classes of this material, viz.: good and bad; the latter coming from those lacking experience and knowledge of the business, and let us use our united efforts to set them right.

If you have a new competitor in your town, go to him, and tell him how to make good work, assist him in getting started right, and it will invariably assist in bringing about a uniform and superior quality of concrete blocks, and result in better profits for both.

There will always be some failures, as there are failures in any business, but by united effort and care, we can reduce these failures to a minimum, and early establish this material in the high class to which it belongs, and our troubles will be reduced to a minimum.

DISCUSSION.

Mr. C. W. Boynton (by letter): Mr. Miracle stated that the block machine people were drawing up a "Standard Specification for Concrete Blocks." It may not be good taste to question the right of the machinery men in this matter, but as Mr. Miracle introduced the subject, I take the liberty to refer to it. I am of the opinion that the block machinery organization will do itself and the block business much more harm than good if they undertake to force a standard specification, no matter how good, upon the makers and users of concrete blocks.

If we were ready to admit that the block machinery organization is the best informed body on the subject, we would still consider it a mistake for them to introduce the specification.

Specifications to ever be accepted as standards, must be promoted by a representative body, in which no one class predominates. And too, no matter how representative the organization in which the specification originates, the co-operation of other organizations in any way interested in the subject must be

had before the specification will be popular.

It seems to me that as all classes interested are represented in this association, such specification should properly originate with this body, and because this body not only represents the block machinery and block manufacturers, but also the architects, the engineers and cement experts, such a move would at once become popular.

Do you suppose that the standard specification for cement would have ever become popular had it been a product of a committee appointed by the manufacturers of cement making machinery, or had the cement manufacturers produced this specification it would not have been acceptable to the engineers and architects nor would the manufacturers have been satisfied had they not been represented on the committee which produced same.

I have no suggestions to make, other than I hope the machinery men will stop and consider and that this association may take proper action toward a specification for concrete blocks.

U. O. Miracle: I have just a few words that I wish to say in answer to Mr. Boynton's criticism. Last summer at our meeting of cement block machinery manufacturers in Chicago we realized that basing our estimates as to the cost of production on different specifications and that it was in order to get this matter on a uniform basis therefore this committee was appointed. Of course we are all very liberal in circulating our literature, and we thought it would be the best for all of us to have a uniform specification to work from, not that we wished to dictate to this association or to the manufacturers of cement blocks what specifications they should use, but we wanted to recommend something that we knew would be inside of a safe limit, and which would not be exaggerating or misrepresenting in our literature.

THE SELECTION OF PORTLAND CEMENT TO BE USED IN THE MANUFACTURE OF CONCRETE BLOCKS.

By Richard K. Meade.*

In every new industry there are some successes and many failures. The concrete block industry has been more fortunate than most new industries, in that heavy demand for building materials of all kinds has made the number of failures less than the number of successes. Whether this condition will last will depend entirely upon the class of work done by the present generation of concrete block manufacturers. If their work is good, if their product proves sightly and buildings made of it turn out to be enduring and sanitary, the failures of the future will be few, and will depend wholly upon a disregard of the law of supply and demand; or an ignorance of the business. If the work of the present generation is poor, if buildings built of its product are unsightly, damp and given to decay and ruin, the failures of the future will, of course, be directly attributable to the poor work of the present day manufacturers.

A general impression seems to prevail that sand is of many grades and must be carefully selected to give a block of good color and the requisite strength. Likewise that each make of concrete-block machine possesses features peculiar to itself which will add to the economy with which the factory can be run or to the quality of its output. Portland cement, however, is thought to be Portland cement, and, like Caesar's wife, to be beyond reproach. One brand is often considered as good as the other, and the whole matter of selection often turns on a difference in price of a few cents a barrel. A sales agent for a large cement plant recently said to me, "My friend, there is no such a thing as bad Portland cement," which was another way of saying "there is a sucker born every minute," and if a cement is not good enough for the careful purchaser who tests his purchase, it can readily be worked off on the careless man who does not.

The concrete block manufacturer needs the best of cement.

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and the future of his business will depend upon his getting this. If he allows his warehouse to become the dumping ground for cement rejected for such heavy, rough undertakings as piers, abutments, foundations, etc., how can he expect the finer and more exacting class of work which he does to last.

It is the purpose of this paper to point out the properties most requisite in Portland cement to be used for the manufacture of concrete blocks. Three all-important qualities of the latter will be dependent upon the cement of which they are made—two of them will be entirely dependent upon it and the third to some extent. These properties are:

(1) Endurance.
(2) Strength.
(3) Color.

The endurance of the block is, of course, an important property, as it makes little difference what strength the building may have when made if in a short time it is to disintegrate. The strength of the block, however, should be such that it will withstand all stresses, strains and loads which may be applied to it, either in the laying of it in the wall or after it is in position and the building completed. The color of the block affects its market ability for superstructure work. To take up the way of attaining these qualities in detail, we will first turn our attention to endurance.

ENDURANCE.

To manufacture concrete blocks which will last and which will retain their strength in spite of the disintegrating action of time, water and gases of the atmosphere, a "volume constant" or "sound" Portland cement must be used. What causes certain cements to swell and expand after mixing with water and allowing them to harden is not certainly known. Those conditions surrounding the manufacture of cement which gives it this tendency are well understood, however, and are usually improper proportioning of the raw material (allowing the lime to be in excess over the silica and alumina) and insufficient grinding and burning of the mixture. This has led most cement investigators to attribute disintegration to an excess of "free lime." This free lime is locked up in a case of hard cement clinker and is almost as effectually protected from water when the cement is made into

concrete as if it were sealed up in a bottle. In time, however, the hard, protecting case of clinker is itself acted upon by the moisture of the atmosphere, etc., and becomes hydrated. The water then has a chance to get at the free or loosely combined lime, and this, in hydrating or combining with the water, expands with great force and disintegrates the now fully hardened concrete; just as water freezing in an enclosed vessel will burst the container, no matter what its strength may be. This is the most complete explanation of the "blowing" or expanding of unsound cement, but be the reason what it may, it is a fact that such Portland cement sometimes expands to such an extent after hardening that the expansion may even be measured, and blocks of concrete made from such cement will sooner or later fall to pieces and disintegrate.

Certain brands are much more liable to this tendency than others. Some mills are provided with insufficient grinding machinery for the raw materials, and can, therefore, seldom make a cement which is sound when fresh. These depend on seasoning to make their product sound, and, hence, when pushed for orders, are very apt to ship fresh and consequently, for them, unsound cement. Lack of knowledge or of skill in manufacture or of system in supervising the process often are the causes of unsound cement. It is probably easier to make a sound cement from cement rock alone than from any other material, and next to this comes the cement-rock-limestone mixture, the difficulty with this growing greater as the percentage of the limestone in the mixture increases. It usually costs less to make an unsound cement than a sound one, because less care is needed in proportioning the raw materials, less grinding is necessary to prepare them for the kilns and less coal may be employed in burning them. Consequently the block manufacturer should exercise care in purchasing cement, to make sure he does not secure cheaply or carelessly made and consequently often unsound cement. If he does secure such a cement, the result will be this: his blocks when freshly made and after "curing" will be sound and hard, and will present no sign of the dissolution, which may ultimately take place with them. They will go out and be laid in the wall of a house. In time, possibly in a year, maybe more, the face of the blocks will begin to crumble and strip off and the blocks will eventually crumble away. This is no exaggeration. I have seen briquettes

made of three parts sand and one of unsound Portland cement, the proportion often used in block manufacture, which, when hardened for a week, stood a tensile strength of over 350 pounds to the square inch, which in less than a year has fallen to a powder, in which almost every grain of sand was separate and distinct, and the cementing agency which had at one time bound them together was merely a mass of light brown powder.

Unsound cement is by no means a rare occurrence either, and there are manufacturers who believe "no cement is bad," and ship fresh from their grinding mills any old thing they happen to be making, whether it passes standard "soundness" tests or not. The cement inspector of a large corporation recently told me that 90 per cent of the cement offered his concern by a certain manufacturer was rejected because of its failure to pass the soundness tests. Are you certain that you did not get any of this cement? I know that cement tests are expensive, yet I know of no better safeguard against unsound cement than the laboratory test. The next best thing is confidence in the knowledge, skill, care and good faith of the manufacturer himself. The concrete block made of unsound cement differs in no way perceptible to the senses to those made of sound. It may not disintetgrate for years, it may, indeed, for that matter, never disintegrate, but the chances are that the blocks made of unsound cement will sooner or later crack and crumble, and the concrete block industry in the sections in which this does occur will very likely receive a serious setback thereby.

It is now generally recognized that seasoned cement is much better than fresh. My own experiments indicate that cement seasoned in bulk for about six months is at its best. Cement which has been kept in bags this length of time, unless stored in a very dry place, may lump, however, and consequently the block manufacturer may have some trouble in making a good sand mixture. There is much to be said in favor of the block manufacturer's buying his cement in large quantities and storing the same for some months. By doing this he will be much less likely to use unsound cement, since unsound cement is often cured or made sound by seasoning. The cement will also gain some in strength. Two objections to storage are the liability of the cement to lump or cake and possibly, in some cases, of its becoming quick setting. The latter tendency is usually met with in low limed and poorly

manufactured cements, though under certain conditions all cements seem liable to become quicker setting with seasoning.

It is a well known fact to those versed in the technology of Portland cement that the addition of plaster of Paris to unsound cement often makes it pass the standard steam test; and that some manufacturers make a practice of so "doctoring" unsound cement. The addition, however, is harmful to cement, as an excess of plaster not only causes the concrete to weaken in time, but also causes unsightly white streaks and efflorescence on concrete blocks. The unsoundness caused by plaster can only be detected by long time tests, so that the usual plan of guarding against it is by limiting the amount of sulphur trioxide found in the cement to 1.75 per cent. Since this is the active constituent in plaster of paris, by determining the amount present (as can readily be done by a chemical analysis) we can calculate if a harmful percentage of plaster has been added to the cement.

While not strictly falling under the title of this paper, it may be well here to mention some causes of unsoundness in concrete blocks, which are not due to the quality of the Portland cement itself, but to qualities which are developed in it by the use of certain chemicals, etc., added to facilitate manufacture or give color. The demend for a quick-setting cement has brought into use the carbonates and hydroxides of potash and soda. These chemicals are the base of nearly all the quick hardeners sold to the concrete block manufacturer. They cause unsoundness to a marked degree and should not be used except upon the advice of an expert cement chemist. They also cause efflorescence on the block.

Some care should also be used to guard against coloring matters for the blocks, which contain chemicals, such as the sulphides or sulphates, chromates, acetates, etc., likely to react with the cement to the damage of the block. Most sulphides are readily oxidized to sulphates, which change is accompanied by expansion and consequently disintegration of the block. Pure oxide colors are best and can be used with safety. Sands with a large percentage of soda and potash minerals (such as mica) or containing pyrites (iron sulphide) are also objectionable for the reasons given above.

STRENGTH.

The strength which Portland cement may develop is due to various conditions of its manufacture, such as chemical composi-

tion, thoroughness of burning, and fineness to which it is ground. As cement is always used with sand, no attention need be paid to its neat strength, unless blocks are to be faced with very rich mixtures. Neat strength is very deceptive and is seldom a reliable indication of sand strength.

One of the most important qualities of Portland cement in determining the strength of the concrete made from it is the fineness to which it is ground. Other things being equal, the finer the cement, the greater will be the strength of the concrete. Thus, a cement as ground by the manufacturer so that 95 per cent of it would pass a 100-mesh sieve, gave a sand tensile strength of 267 pounds in seven days, while the same cement, ground to all pass a 200-mesh sieve, gave 375 pounds for the same period, or an increase of 40 per cent in sand strength due to finer grinding.

In this connection it may be said that fine grinding seldom increases the neat test any, and indeed, as a general thing, lowers this, so that high neat tests when given without the sand tests may be regarded as meaningless. The particles of cement retained on a 200-mesh sieve are entirely inert and may be looked upon as just so much aggregate. If these particles are sieved out and the attempt is made to make a block of them, it will be found impossible to get the mass to cover. Exactly how small the small particles must be before they will be acted upon by water no one has yet determined, but it is known that of the material passing a 200-mesh sieve some of it at least is not fine enough. This has an important bearing on the value of the tests for fineness. For example a cement, all of which is ground just sufficiently fine to pass a No. 200 sieve, is not in reality so fine as a cement ground in such a way that while some of it fails to pass a 200-mesh sieve, still the greater part of that which does is a more or less impalpable powder. Similarly for cement ground 85 and 95 per cent through the 200-mesh sieves by *rolls* and cement ground 75 per cent fine by other methods.

Since the particles of cement retained on a No. 200 sieve are inert, the purchaser may look upon all of such coarse materials as so much waste matter, whose place can be taken by sand without detriment to the resulting concrete.

Probably all concrete block manufacturers are striving for a waterproof block—one in which all the voids are filled. This latter may be achieved by the use of a richer mixture, by water-

proofing compounds, or preferably by the employment of a sand containing the proper proportion of fine particles. These fine particles help to fill the interstices between the coarse ones and to so keep out the water. One of the oldest principles of good concrete is "to coat the particles of sand with the cement paste" and that the strength of the concrete is proportionate to the thoroughness with which this has been done. Now, the finer a body is pulverized, the more surface it will present. Thus, if we divide a cube an inch square into halves, we will increase the surface area from 6 to 8 square inches, and if we quarter it will increase to 10 square inches, etc. Consequently the finer the sand we use, the more surface there will be to coat, and for exactly the same reason the finer must the cement be to coat this sand.

By using a sand containing fine particles and a finely ground cement, in place of a richer mixture, fine cement is made directly more economical than the coarsely ground one.

By "fine cement," however, is not meant a cement ground by rolls, etc., to show a good sieve test, but a cement which contains a large percentage of flour. Since in such a dense concrete there are no voids, or practically none, there is no room left for the expansion of the cement during hardening, as is the case with ordinary porous concrete, where the cement can usually expand a little into the spaces between the sand grains, and it is doubly important to use a sound, or, in other words, a non-expanding Portland cement.

The setting time of Portland cement also has an important influence on the strength. Slow setting cements—that is, cements which get their final set in from four to nine hours, are much stronger than those which set more quickly. Quick-setting cements are nearly always over-clayed and contain less of the active silicate and aluminate of lime, to which cement owes its strength, than the slower setting ones. This may seem paradoxical, but it is nevertheless true. The compounds in cement which set quickly are not those which give it great strength, consequently cements giving an initial set of less than thirty minutes, are hardly ever as strong as those which require two or three hours. For example, a cement which sets in thirty minutes rarely ever, unless very finely ground, gives a seven-day sand test of over 250 pounds, while one with a set of two or three hours may easily give 300 to 350 pounds, or even more. Cements with a "flash" set—that is, which

set up under the trowel—should not be used in making blocks, as these latter are apt to be weak. With such cements the set is broken by working, the processes of solution and crystallization are interfered with, and consequently the cement has only half a chance to do its work. The set of the cement should always be sufficient to give ample time to mix the mortar and fill the machine, or molds.

One of the greatest requisites of Portland cement to be used for concrete blocks is that it shall be a quick hardener. It must get its strength promptly. By prompt hardening is not meant quick-setting cement. The term "set" is merely used to define the change undergone by the mortar in passing from the plastic to the solid state. The hardening only begins after the setting process is completed, and quick setting cements are not necessarily prompt hardeners; and are indeed usually the reverse.

The best test for prompt hardening is the seven-day sand strength. Cements which get a tensile strength of 300-350 pounds per square inch in seven days are now on the market, and these are best suited to concrete-block manufacture. If the blocks do not lose strength, the sooner they get their full strength the better, because the sooner they can be used, as less time is needed to cure them. A cement which has a sand strength of 350 pounds after seven days, and which has only increased 50 pounds in a year, is to my mind much better for the purpose than one which has a strength of 200 pounds at seven days and increased 150 pounds in the same length of time, because it will stand if it is a year old. A building may have to bear its full load three months after the blocks are made, and hence the prompter hardening cements are needed for block making.

Below is an example of the two classes of cements, prompt hardeners and those with what their manufacturers point to as a progressive increase:

	7 days.	28 days.	3 mos.	6 mos.	1 year.	2 years.
Prompt Hardener....	375	382	380	395	415	415
Progressive Hardener....	212	275	282	312	360	366

Cements made in the old-fashioned upright kilns are all slow hardeners, while the best rotary kiln cements are usually prompt.

About 1890, those who still used the upright kilns in America, and the German manufacturers, who used them exclusively, and who also at that time imported largely into this country, used this argument continually to keep the rotary cements out of the market. Portland cement should show a slow progressive gain for a period of ten years or more. It is interesting in this connection to remark that the German scientists must now be satisfied that prompt hardening cements are all right, since they are rapidly replacing their upright kilns by rotary kilns, and some of their leading scientists have become the champions of high-lime, prompt-hardening cements.

A prompt hardening cement and a slow hardening cement can be made from the same batch of clinker, as the burned unground cement is called, by grinding one lot coarse and the other fine. If the coarsely ground is "volume constant" or "sound," it will usually give a cement which gives low tests at first and finally fairly high ones. The finely ground cement, on the other hand, will give tests which are high at first and increase very little comparatively with time. This shows that slow hardeners are merely Portland cements with more or less slowly acted upon material in their makeup. This material may be either coarse particles of cement or material of feeble hydraulic properties, which only begins to hydrate after a long period in water. Portland cement can also be made slow hardening by additions to it of such substances as ground slag, limestone, cement rock, Rosendale or natural cement, etc.

All rotary cements are not prompt hardeners, as chemical composition as well as methods of hardening influence this. Prompt hardening cements usually cost slightly more to make than slow hardeners, as the former usually contain a higher percentage of lime. This necessitates finer grinding of the raw materials and harder burning to make a sound cement.

Unsound cements give high short period tests, which fall off remarkably with time, until ultimately the briquettes may fall to pieces of their own accord. Prompt hardening cements often give neat tests which are high at seven days and fall off somewhat after that period. The old theory was that this showed internal agencies at work disrupting the briquettes, but it is now generally accepted that if the cement is sound, falling off in strength as the cement hardens it becomes brittle and more easily broken

by the sudden jars, torsional strains, etc., to which the briquettes are subjected in testing. Sand tests, both tensile and compressive, made of the same cement seldom show any marked falling off, and hence, since cement is always used with sand and in compression or abrasion, no attention need be paid to the brittleness of the neat briquettes. Where, however, blocks are to be faced with rich mixtures, such as one of cement to one and two of sand, some attention may be given to neat tests also, or, better still, special briquettes may be made, using the proportions to be employed in facing the block. If the latter cannot be done, cements giving good neat tests should be employed, and since unsound cements are more apt to give trouble in rich mortars than in lean, for the reason explained before, only well-seasoned cement should be used. Concrete blocks are now sometimes waterproofed by coating their exposed surface with a thin layer of paraffin. This thin layer effectually protects the interior of the block from the moisture of the air, and, as cement can only harden by hydration (absorption of water), the block cannot gain in strength after it is so coated. Consequently, where waterproof blocks are made, prompt hardening cements should be used, and the block should be allowed to gain good strength before applying the coating. For a similar reason these blocks should not be made too dry.

In connection with the use of waxes, etc., for waterproofing, it may be well to state that certain waxes and fats are very likely to decompose in time with the formation of "fatty acids." These acids attack the concrete by dissolving out the binding agent, hydrate of lime, from between the sand grains. Pure paraffin, however, does not decompose into fatty acids, but some animal fats and vegetable waxes are very likely to do so.

COLOR.

The concrete block manufacturer will probably be more interested in the color of his blocks than in any other one of their properties, since upon this will depend the immediate marketing of his product. Uniformity of color is, therefore, very important to him, since the color of a building, in order to be pleasing, should present a uniform appearance to the eye. Uniformity can only be secured by making the block of uniform cement and sand mixed in definite proportions and manufactured into blocks under as nearly the same conditions as it is possible to obtain. For colored blocks dark colored cements may be used, but their color

should be uniform. For lighter blocks, light colored cements must be used. As the color of cement gets lighter as it is ground finer, only finely ground cement should be employed for this work. The percentages of iron and manganese in the cement also influence the color. Cements free from iron and manganese would be white, and the color darkens as the percentage of iron or manganese increases. Most cements are practically free from manganese, and hence the color is usually due to iron.

Sulphate of lime, which is always added to cement to regulate the set, is one of the causes of the white efflorescence seen on concrete blocks. This salt is soluble and is carried to the surface of the block by the water which "sweats" out during curing. The less sulphate of lime present in cement intended for concrete block manufacturer, the better. As Portland cement can be obtained which contains less than 1.5 per cent sulphuric trioxide (the chief constituent of the sulphates and the way they are usually reported in a chemical analysis), it is hard to see why cement containing more than this amount should be used.

The alkalies are also soluble salts, and are to some extent responsible for the saline efflorescence on concrete. Cements low in these should, therefore, be used. Most American Portland cements, however, contain less than 1 per cent alkalies.

Sulphide of iron is sometimes met with in cements burned in upright kilns. This causes dirty brown splotches to appear in the work from the oxidation of the iron to brown oxide of iron or "rust." Over-clayed cements also show the same dirty brown color throughout the mass, as in such cements the iron seems to be present as the red brown "sesquioxide," instead of the black "magnetic" oxide of well made cements.

DISCUSSION.

Mr. C. W. Boynton (By Letter.)

One might infer from Mr. Meade's paper that he advocated the testing of cement by cement block manufacturers. I do not believe that Mr. Meade intended that he should be understood just this way, for he knows too well the difficulties met with and which must be overcome before cement testing may be successfully done. From what I have heard in this convention, I should judge that the block manufacturer now had about as many difficulties to overcome as he would care to consider at one time. He is not in the business long before he discovers that the personal equation enters largely into block making; but should he undertake to test his cement he would be up against a much greater bugbear. The block business may be vexing, but not comparable in the same breath with cement testing. It is only after long experience that one may obtain results that are at all reliable.

It is not because of any unwillingness on the part of the manufacturer to submit his cement to test that I am prompted to make these comments, but after several years' experience in cement testing I fully appreciate the difficulty met with. Should the block manufacturer think it necessary to have his cement tested, I would by all means suggest that he submit his samples to some reputable laboratory for examination. I do not consider the danger from bad cement as great as one might infer from Mr. Meade's paper, and would suggest in this connection that you try to recall the number of failures you have met with, such as described by Mr. Meade, which might be due to unsound cement I know there has been a tendency on the part of the block manufacturer to blame the cement for the majority of his difficulties, but this was probably due to the fact that he thought the blame should be fixed some place, and as there would be no satisfaction in blaming nature for either sand or water, he has fixed the blame upon the cement. The manufacturer of concrete blocks will be well repaid for any time spent in studying carefully the results

obtained in his own factory. I cannot conceive of time being spent to better advantage, for the business is yet in its infancy, and there is so much more to learn than we now know, that close study of results is necessary if one expects to make progress.

The cement manufacturer is only a little less anxious than yourself that the block business should prove a splendid success.

LEGISLATION CONCERNING THE USE OF CEMENT IN NEW YORK CITY.

R. P. Miller.

The prime function of a building law is the protection of the general public against the dangers resulting from:

1st. Bad construction,
2nd. Hazardous surroundings,
3rd. Defective equipment,
4th. Inadequate means of escape,
5th. Unsanitary conditions.

The enforcement of such law is included in the police powers of the state or municipal government.

The third, fourth and fifth of the dangers above specified may be entirely dismissed from consideration in this paper. They relate to the supplying of proper fire-fighting appliances in structures and the affording of good and sufficient means of escape from fire or panic to the occupants of buildings, and securing healthful surroundings for them. They apply equally to all kinds of constructions, irrespective of the materials used. The other two dangers, bad construction and hazardous surroundings, do very materially concern the question under discussion.

The dangers of bad construction would include those due to bad materials, bad workmanship, including incompetent supervision, and bad design. (This is not the logical order, but this order is taken for convenience in this discussion.)

The dangers of hazardous surroundings are those attending the inability of a building to withstand attacks from outside sources such as excavations on adjoining premises, but more particularly fire in adjacent structures. When we have provided against these in our laws, we have secured the essential requirements that constitute a satisfactory law.

It is the object of this paper to consider what these requirements are, so far as they apply to the use of cement, and especially from the standpoint of one who has been called upon to administer the law for a period antedating the present phenomenal growth in the cement industries.

Cement is used in different ways in building construction: most extensively in mortar. very largely in concrete, both plain and reinforced; in increasing quantities in building blocks, also for cement blocks, artificial stone, stucco, and in perhaps other less important ways. In whatever way cement may be used in construction, its quality should be up to a certain standard, and it is properly within the province of the law-making power to fix that standard, or at least to recognize some standard otherwise established and recognized. This may be done either by giving a complete specification in the law, or authorizing the executive officer of the building bureau or department to prescribe, within proper restrictions, the requirements which all cements must meet. The former way is the less desirable, not only in the particular matter under discussion, but in all building laws, as it retards progress and makes no provision for new materials and processes or improvements. Building laws should be sufficiently flexible to be capable of meeting new conditions. This can be best accomplished by laying down in the law only fundamental principles and investing the executive officer with power to fix the more definite requirements. That this power may not be abused, it should be restricted to such an extent as to require the publishing of all proposed requirements, and the holding of public hearings, if demanded, before the same become effective.

In the case of cement, the fundamental principles should be such as to secure strength and soundness. As to the more specific requirements, nothing better could be done than to adopt a standard specification promulgated by some organization of recognized national reputation, such, for instance, as that of the American Society for Testing Materials. No specification ever drawn satisfied everybody, but one presented by such an organization, though it does not in some particulars meet the views and criticisms of the building official immediately concerned, has great weight.

As to strength of cement, the present Building Code requires the tensile strength of neat briquettes to be:

For Natural Cements:

After 24 hours set in air, 60 lbs. per sq. in.

After 1 day in air and 6 days in water, 120 lbs. per sq. in.

For Portland Cements:

After 24 hours set in air, 120 lbs. per sq. in.

After 1 day in air and 6 days in water, 300 lbs. per sq. in.

In the case of the natural cements the requirements are still considered satisfactory, but for Portland cements the accepted present standard is higher, namely:

After 24 hours in air, 200 lbs. per sq. in.

After 1 day in air and 6 days in water, 500 lbs. per sq. in.

That is fully 66 2-3 per cent better than the old standard.

This illustrates, in a measure, what has been said about the flexibility of law. As conditions improve, it should not be impossible for the building official to demand the use of the up-to-date material.

Neither the New York Building Code, nor any other building law that has come to our attention, makes any provision for soundness, and yet this would seem to be the more important characteristic of a cement. A contractor or speculative builder would possibly not care whether his structure lasted beyond the final payment or the transfer of the property, but the interests of the public demand that it shall. In some cases self-interest would also require lasting qualities. The manufacturer of concrete building blocks or cement brick could not afford to have his product disintegrate in six months or a year after it had been put into a building, and yet that would happen if his cement should be unsound.

So long as cements were used in constructions where the individual masses were large and unbroken, the importance of soundness in cement was not so apparent. But since the introduction of building blocks, and especially of reinforced concrete construction, this matter becomes of first importance. Imagine, if you will, the consequence of the disintegration of a concrete column, due to unsound cement, in the basement of a heavily loaded five-story warehouse.

The municipal inspection bureau could not, of course, inspect all cements used in the building operations, nor is it the function of the government to do so. The law should require, however, as it does in New York, that all brands of cements be tested under the supervision of the proper official at such times and as often as may be deemed necessary; that a record of all cements answering the lawful requirements be kept for public information; and that no other cement be used.

The law should further prescribe that all cement used in important work, especially in work where the masses in the individ-

ual members composing the structure are comparatively small (compared to the entire mass), such as reinforced column and floor work or building block manufacture, should be tested for strength and soundness by the contractor or manufacturer at some reputable laboratory, and a certified copy of such tests filed with the proper building official.

Mortar and concrete, it may be said, are the forms in which cement for building purposes is always used. It is, therefore, quite within the province of the law to describe the characteristics of the other component materials. These may be one or several of a number of materials: sand, gravel, broken stone of many varieties, slag, cinders, broken brick, etc. The extent to which any of these materials is used will depend largely on local conditions. The proper proportions in which they are used varies with the material and the size used. To get the best results the mixture must be well balanced, and other characteristics for materials, of this nature, and the conditions under which tests shall be made and approvals issued. The requirements conditioning the acceptance of the materials were based on the results of an elaborate series of tests on common brick as delivered in the New York market, and on the theory that any new material should be at least as good as that most commonly used. These regulations containing the requirements were published in the technical journals, and it was hoped at the time that they would bring forth such discussion and criticism as would be useful in determining whether the requirements were fair or perhaps too severe. Thus far no objections based on reliable data have been made, and this is probably due to the total lack of definite informtion.

Section 14 of the New York Regulation is as follows:

"14. The following requirements must be met to secure an acceptance of the materials: The modulus of rupture must average four hundred and fifty and must not fall below three hundred and fifty in any case. The ultimate compressive strength must average three thousand pounds per square inch and must not fall below twenty-five hundred in any case. The percentage of absorption (being the weight of water absorbed, divided by the weight of the dry sample,) must not average higher than fifteen per cent and must not exceed twenty per cent in any case. The reduction of compressive strength must not be more than thirty-three and one-third per cent, except that when the lower figure is

still above three thousand pounds per square inch, the loss in strength may be neglected."

The Philadelphia Building Bureau adopted these regulations in toto at the time, but have recently modified them so far as they relate to concrete building blocks. Their requirements are as follows:

"14. The following requirements must be met to secure an acceptance of the materials: The modulus of rupture for concrete blocks at 28 days old must average 150 and must not fall below 100 in any case. The ultimate compressive strength at 28 days must average 1,000 lbs. per sq. in. and must not fall below 700 lbs. in any case. The percentage of absorption (being the weight of water absorbed, divided by the weight of the dry sample,) must not average higher than 15 per cent and must not exceed 20 per cent in any case. The reduction of compressive strength must not be more than 33 1-3 per cent, except that when the lower figure is still above 1,000 lbs. per sq. in. the loss in strength may be neglected."

We are not prepared to defend these requirements against all criticism; in fact, any information of tests that would establish the correctness or unfairness of these requirements would be most welcome. This much, however, must be said, that thus far several new materials have met the New York requirements, and among them cement brick. No concrete building blocks have yet been tested in accordance with these requirements. While it would seem that some change is desirable for the benefit of the building block, it is believed that the Philadelphia requirements are too low. It may be true that by virtue of the larger size of the units, a wall built of building blocks has some advantages of strength over one built of smaller units, such as common brick, still so great a drop in ultimate compressive strength below that required for brick or stone concrete as is permitted by the Philadelphia regulations seems unreasonable. No one contends that an ultimate compressive strength of 2,000 pounds at 28 days for concrete or of 2,500 pounds for brick is too high, yet it is proposed to accept building blocks with an ultimate compressive strength of 1,000 pounds at 28 days, and even then make no provision for extra thickness in a wall built of building blocks above that required for brick or Portland cement concrete.

In the case of reinforced concrete, however, the question of

the mixture must be disposed of in a different manner. Reinforced concrete construction is put up in place. The component parts—concrete and steel---are differently disposed for varying conditions of shape, span and loading. The entire construction must be carefully planned beforehand—every part must be definitely fixed, and the size and position of each element must be determined by calculation. In order, therefore, that any governmental control in such case may be had, a definite mixture must be used, the physical characteristics of which, crushing strength, modulus of elasticity, adhesive power, resistance to shear, are well known; and the law-making power is fully justified in prescribing such mixture for all work of that kind under its jurisdiction. What that mixture should be will again depend somewhat on local conditions, for it would certainly be out of all reason to prescribe a trap rock mixture in a locality where trap rock is commercially unobtainable.

The New York regulations permit a variation in the mixture from the prescribed proportions of 1-2-4, so long as it can be demonstrated by tests, under the supervision of the bureau, that the compressive strength at twenty-eight days does not fall below 2,000 pounds per square inch. Experience has shown that very little latitude should be allowed in this matter of variation of mixture, as it is practically impossible to properly control the construction where more than one mixture is used. If the designers could be held criminally responsible for their results, no limitations of this kind would be needed; but so long as the building authorities are held to a partial accountability, they are fully justified in insisting on a single well-known mixture for reinforced concrete construction.

Before dismissing this question of materials and mixtures, one other commonly used mixture should be considered, namely, cinder concrete. The excellent fire-resisting quality of this concrete makes it a most useful building material. Its great lack of uniformity and its consequent unreliability in strength makes it necessary to deprive it of consideration as a construction material whose strength is calculable. The practice in New York is to insist on load tests on full-sized constructions for every variation in span and detail of construction, in order to determine allowable working loads.

Floor constructions are here alluded to, as that is practically

the only form requiring strength in which it is used. The factor of safety demanded is ten; that is, the section of floor to be tested is loaded till it breaks, and one-tenth of the uniformly distributed breaking load is taken as the working load.

Good workmanship is important in all construction, but in no form of construction is it so imprtant as in reinforced concrete; and in that form of construction it is no more nor no less important than good materials or good design. So far as the law is concerned, however, workmanship may be dismissed in a few words. The law can simply demand that all possible care be exercised in securing it. It will always be secured if there is competent supervision. Competency is secured by study and experience. It is not necessary to go into such details as cautioning against freezing mortar, using cements that have begun to set, where there is competent supervision. There would be no end to these detailed requirements if once begun. How to secure competent supervision in all cases, especially where builders and owners are unwilling to pay for it (though it is an excellent investment), is a difficult problem. The following suggestions may, however, be a step toward the solution: Let it be made compulsory that every building operation shall be in charge of a licensed inspector or superintendent, who shall have received his license from a competent examining board, and who shall be criminally responsible for the work and for infraction of the law. The details of this plan have no proper place in this paper, for they are of general application and not peculiar to this form of construction.

For a design of a structure the designer must always be reasonable. The supervision of the design by the building authorities should only be to assure that the allowable working stresses have not been exceeded, that the prescribed floor capacities are provided, that proper light and ventilation are secured, etc.; in fact, that the general provisions of the law are complied with.

To go beyond this is to relieve the designer of that much responsibility and to place it where it does not belong. Building departments or bureaus should be bureaus of record, and their records should be complete. The Prussian regulations on reinforced concrete go so far as to even demand that a copy of all

calculations as to strength be filed, although they may not be checked over.

There is a great tendency to particularize in our laws and to add provision upon provision, to make more and more a complete specification of the law. Instead of this, as has already been stated, only fundamental principles should be included in the law. The designer should be allowed all possible freedom, but, at the same time, he must be made absolutely responsible for his work.

So long as these conditions do not obtain it is, perhaps, better that the law should go further than necessary in prescribing limitations. Under such circumstances it is to the interest of the good and honest designer and builder and users of cement that the law should err on the safe side and take a conservative position.

New York City was the first municipality in this country to prescribe regulations on the use of reinforced concrete. They were drawn after much study and considerable discussion among experts at a time when the construction was not widely known. That they have been fair and good is attested by the fact that with not many changes the requirements on that form of construction, laid down in the model building code recently proposed by the National Board of Fire Underwriters, are those of New York City. And these latter requirements were, as stated by one closely connectel with this promulgation, the result of study, of suggestions and criticisms of many engineers and experts. Besides these two codes there are ordinances in Chicago, Cleveland and Denver.

Taking up in more detail the fundamental principles to be laid down for the guidance of the designers, these should include:

1. The allowable stresses in the materials.
2. The methods used in calculating the stresses produced.
3. The guiding principles in determining the resistance to these stresses.

It is generally conceded that the tensile strength of concrete should not be considered.

The New York, Chicago and Cleveland laws prescribe working stresses, but the proposed code of the National Board of Fire Underwriters prescribe a factor of safety applied to working loads and the use of ultimate stresses. It is not proposed to discuss here the superiority of either method over the other, as both will give safe results if intelligently used.

The following stresses should be used, and are those prescribed by the law cited, the ultimate stresses being those used by the National Board of Fire Underwriters:

	Working stress	Ultimate stress
For extreme fibre stress of concrete in compression.....	500 lbs. per sq. in.	2,000 lbs.
For shearing stress in concrete..	50 lbs. per sq. in.	200 lbs.
For concrete in direct compression.....	350 lbs. per sq. in.	
For tensile stress in steel.....	16,000 lbs. per sq. in.	Elastic
For shearing stress in steel....	10,000 lbs. per sq. in.	Limit
For adhesion of concrete to steel..	50 lbs. per sq. in.	200 lbs.

The Denver ordinance gives no stress values, but refers to a hand-book, a practice that is not to be commended. The Chicago ordinance permits a shearing stress in concrete and adhesive value of 75 lb. per sq. inch, which, in the opinion of the writer is too high. On the tensile value of steel there is also a difference, only New York and Clevland fixing a definite figure—16,000 lbs., and Chicago permitting one-third of elastic limit. On this point there is much opportunity for discussion. The writer believes a definite value should be adhered to, and that should be 16,000 lbs. working stress.

It is generally believed that the adhesion of concrete to steel may be taken the same as the shear to concrete. The Denver law, however, prohibits the use of plain bars. This is an unjust limitation on the designer, as long as the safe limit of adhesion is not exceeded. When this occurs, all the laws are agreed that other provisions should be made. So, too, would it be an unfair requirement to prescribe the use of stirrups unless the safe resistence to shear is exceeded, or to insist on the use of certain bars to secure rigid attachment of the stirrups. This is no more important than the placing of the tension bars in their exact position, which must be taken care of in the supervision of the construction.

The Cleveland law makes provision for compression in steel. This is unnecessary, as the allowable compression in the steel must depend on the assumption of the ratio of moduli of elasticity of the two materials, unless the steel is designed to take all the load, in which case we are no longer dealing with reinforced concrete.

The maximum ratio of length to diameter of columns is fixed at twelve in all but the Denver law, where hooping is required, when the ratio exceeds four.

In the calculation of bending moments and the determination of moments of resistance, the practice is quite uniform and the New York provisions are suggested as sufficiently full. The following assumption shall guide the determination of the bending moments due to the external forces. Beams and girders shall be considered as simply supported at the ends, no allowance being made for continuous construction over supports. Floor plates. when constructed continuous and when provided with reinforcements at the top of plate over the supports, may be treated as continuous beams, the bending moment for uniformly distributed loads being taken at not less than WL-10; the grinding moment may be taken at WL-20 in the case of square floor plates which are reinforced in both directions and supported on all sides. The floor plate to the extent of not more than ten times the width of any beam or girder may be taken as part of that beam or girder in computing its moment of resistance. The moment of resistance of any concrete-steel construction under transverse loads shall be determined by formula based on the following assumptions:

(A). The bond between the concrete and steel is sufficient to make the two materials act together as a homogeneous solid.

(B). The strain in any fibre is directly proportionate to the distance of that fibre from the neutral axis.

(C). The modulus of elasticity of the concrete remains constant within the limits of the working stresses fixed in these Regulations.

From these assumptions it follows that the strees in any fibre is directly proportionate to the distance of that fibre from the neutral axis.

The tensile strength of the concrete shall not be considered.

It is believed that these provisions go as far as necessary (they are somewhat elaborate in the National Board of Fire Underwriters' Code), and do not hamper the designer unneccessarily For a comparatively new form of construction, in which uniform practice is not yet thoroughly established, it cannot be said that they go too far.

Regarding the use of concrete building blocks in the design of

new buildings, an important question arises as to the height to which they shall be allowed in walls. Chicago restricts their use to dwellings and stables not more than two stories in height. Cleveland allows them for buildings of ordinary (non-fireproof) construction four stories in height. Philadelphia permits them for six-story buildings. Their use is not yet allowed in New York (Manhattan).

Concrete is generally assumed and frequently accepted as fire-proof. The later laws on concrete recognize it as fire-proof and prescribe minimum thickness to be used for covering the embedded metal. That concrete is incombustible cannot be denied, that it will not disintegrate under fire cannot be maintained (stone and gravel concrete only is being considered now). The New York building authorities have made fourteen fire tests on concrete constructions, of which seven proved successful. It would seem that in the cases of failure the concrete when tested was too green, that is to say, it contained too large a percentage of uncombined water which was converted into steam and caused the disruption of the concrete. This makes it necessary to guard against the occupancy of concrete structures, within the time required for the concrete to oppropriate all its water. That a reinforced concrete building is far superior as a fire-resisting structure to a mill constructed building must be conceded; that it is equal to the best type of fireproof construction cannot justly be claimed.

The best practice in this particular is that given in the code of the National Board of Fire Underwriters, as follows:

"Reinforced concrete construction may be accepted for fireproof buildings if designed as hereinafter prescribed provided, that the aggregate for such concrete shall be hard-burned broken bricks or terra cotta, clean furnace clinkers, entirely free of combustible matter, clean broken stone, or furnace slag, or clean gravel together with clean siliceous sand, if sand is required to produce a close and dense mixture; and provided further that the minimum thickness of concrete surrounding the reinforcing members 1-4-inch or less in diameter shall be one inch; and for members heavier than ¼-inch the minimum thickness of protecting concrete shall be four diameters, taking that diameter in the event of bars of other than circular cross-section which lies in the direction in which the thickness of the concrete is measured; but no protecting concrete need be more than four

inches thick for bars of any size; and provided, further that all columns and girders of reinforced concrete shall have at least one inch of material on all exposed surface over and above that required for structural purposes; and all beams and floor slabs shall have at least three-quarters inch of such surplus materials for fire-resisting purposes; but this shall not be construed as increasing the total thickness of protecting concrete as herein specified."

Of the fire-proof quality of cinder concrete there can be no question as already intimated. The thirty-six tests made under the supervision of the New York Building Bureau would remove any doubt in the matter.

Of the fire-proof character of building block walls very little is known. Information is much desired.

The weathering qualities of concrete, more especially in the shape of building blocks, should be fully and carefully investigated. Some freezing tests made for the New York Building Bureau on cement blocks, indicated a tendency of the material to distend, and a loss in compressive strength of about 40 per cent resulted. On concrete building blocks the absorption is probably high (this is not based on actual observation) and a corrugated deterioration of the material in freezing seems likely. To guard against danger in this respect the following New York provision is desirable.

"That the freezing and thawing process must not cause a loss in weight greater than 10 per cent, nor a loss in strength of more than 33 1-3 per cent, except that when the lower figure is still above 3000 pounds per square inch, the loss in strength may be neglected."

To this may be added that if the lower figure is still above 2000 pounds per square inch, the loss may be as much as 50 per cent, but no more.

In conclusion it may be said, that of all the suggestions, made in this paper, the most important is the one fixing the responsibility for bad design and bad workmanship. It is decidedly in the interest of every cement user, that so valuable a structural material as cement, should be applied honestly and intelligently, leaving no chance for its condemnation because of improper or irresponsible work.

DISCUSSION.

Mr. Chas. D. Watson: This is the paper I have been waiting for. The New York building laws are slightly unjust to the manufacturer of cement products, and the writer would like to ask a few questions. I understand the requirements for compression are 2500 minimum and 3000 average.

Mr. Miller: 3000 average of five specimens, or not less than 2500 in any case at the age of 28 days.

Mr. Watson: The manufacturers of the best cement stones know that the slower the cement sets the better the block, and therefore do not allow a stone to go out of the factory in less than 28 days. Mr. Miller makes the statement that the specifications were intended to require the use of material equal to that in common use at the time. Do I understand that the maximum absorption is 15 per cent?

Mr. Miller: The requirements are that the average absorption on five specimens shall not be more than 15 per cent, and shall not exceed 20 per cent in any case. These requirements were based on the results from about 50 tests, 25 of which were absorption tests made about a year ago on common brick as delivered in the New York market. The average for brick showed the absorption to be 15 per cent, with a maximum of 21.4 per cent.

Mr. Watson: The brick that I am accustomed to usually show an absorption of from 18 to 20 per cent, and hence I would like to ask whether he does not consider 15 per cent rather low, considering the brick as it runs throughout the country?

Mr. Miller: I am inclined to think so. I have found since we have completed that regulation, by comparing our results with those obtained elsewhere, that we probably get an unusually good brick in New York. In basing the requirements of our regulations on the results of those tests on common brick, the authorities were guided by the law which specifies that the working compressive stress on common brick shall be taken at 300, and which further provides that this shall represent a factor of safety of 10; so that the authorities said that they have no right to say "We shall accept something that is less strong than that."

The average compressive strength developed in the brick was a little over 3000 lbs. per square inch, showing that the material did come up to what the law expected it should. But we found also that a number of them fell below that point. The law also provides that you may lay up masonry, brickwork, in Portland cement mortar, and load it to 250 lbs. per square inch. That of course, with a factor of safety of 10, would require an ultimate strength of 2500 lbs. per square inch. I would also say that I came to this convention in an official capacity to learn something about building blocks. We know very little about it in New York, especially in Manhattan, because there is probably little field for it in a city where the lowest buildings are probably five stories and more in height. We feel that the only way to keep any control over the use of building blocks is to establish some standard of strength and what that should be and what restrictions should be placed on the use of building blocks is what we would like to know, and I am here as much to ask questions as I am to give what information I can.

Mr. Watson: Why was 28 days taken as the final test?

Mr. Miller: The regulations do not say 28 days. The regulations provide "that the samples may be tested as soon as desired by the applicant, but in no case later than 60 days after manufacture. "That was made purposely 60 days to give a little advantage to cement products. It is possible to have a building under full load 60 days after making the blocks and they should at that time show the strength for which they have been figured

Mr. A. N. Pierson: Mr. Miller is here for information. Just as a suggestion how would it do to incorporate in the requirements that the blocks shall be manufactured at least 60 days before they are delivered upon the work, which gives them that time in which to mature, and then another 60 days before they were allowed to be used?

Mr. Miller: I think that is a very good suggestion. I am particularly interested in determining a fair compressive strength to require of the concrete block at 28 days, and in deciding on a transverse test. I also had in my mind the percentage of open spaces in the blocks and the minimum allowable thickness of the shells. Those have been partially answered. There is another point. Shall they be restricted to 3, 4 or 5 story buildings, or shall they be used in any building?

Mr. Watson: I would like to ask the chair a question. Do you consider that with a strength of 2500 to 3000 lbs in 28 days the concrete is high or low?

President Humphrey: High.

Mr. Harper: I would like to ask Mr. Miller whether one must bring samples of concrete blocks to the New York department to be tested within the 60 days so that they can be tested at the 60 days, or can older material be brought.

Mr. Miller: We are not particular as to the date when the test is made. We feel that the regulation should be observed, and the test should be made before or at the time when the block is 60 days old.

Mr. Seafert: In your specifications, do you permit the use of bituminous cinder, or do you restrict it to anthracite, and is there anything in your regulations regarding the presence of sulphur?

Mr. Miller: No, sir; we have no restrictions in regard to the use of cinder concretes. Good clean cinders, or commercial cinders, is all we expect to be mixed with the sand, generally in the proportion of 1, 2, and 5. The mixtures are not always uniform. Some manufacturers of floors use 1 to 7 without sand, and others use 1 to 2½ and 6. Each system as tested is permitted to use the proportions that were used in the test structure.

Mr. Seafert: The insurance laboratories after making extensive tests found that the bituminous cinders were injurious, and where sulphur was contained in them the iron had been destroyed.

Mr. Watson: I would like to bring out another point in regard to the 28 days. We found from experience that the product, when tested at 28 days, will often run as low as 1800 to 2000 lbs., but the same stone when tested in 60 or 90 days will run as high as 4000, due to the fact that we endeavor to retard the setting when the stone is made. It seems to me that a by-law of that nature does an injustice to the manufacturer who is endeavoring to make the best material by so retarding the set in order to get an even drying out of the product. That is the point I was trying to get at.

Mr. Miller: I think the critisism is a just one. At the time these regulations were framed concrete blocks were not really in mind; they had not been suggested and we were then leading another form of new material, the sandlime brick.

LEGISLATION ON CONCRETE BUILDING BLOCKS.

By Will J. Scoutt.

All legislation for the control of the use of cement or concrete building blocks in the construction of structures of various classes, is found in the ordinances enacted by the Common Councils or Boards of Aldermen of our larger cities. Comparatively few such ordinances have been passed. Those that have been enacted, exhibit as wide a range in clearness and lucidity, obscureness and scope, as the range of human intelligence floating on a sea of uncertainty, without chart or compass, and, apparently, in many instances, without knowledge of the subject matter, can devise.

No two are alike. Some permit the use of concrete blocks in buildings but two stories high and confine their use to residences, others permit their use in six-story structures of various classes. These classes and sub-divisions thereof, are unlike in the different building codes, and the use of blocks in certain classes in one city cannot be adopted for the same class in another city, as it relates to entirely different structures. Some of these ordinances are very brief; others very prolix. In some, what is intended to be made very plain in one section, is obscured by another section. Certain specifications in one ordinance are so clear and specific that if adopted and followed, literally, by a manufacturer of the blocks in one section, using the best materials obtainable there, and exercising the best skill of a high class workman in his line, in an attempt to make the strongest product possible, with such materials and workmanship, will produce a stone that will not fulfill the requirements of another section of the same ordinance. Another manufacturer, in a different community, having at hand materials for good concrete, if compelled to follow, strictly, the lines specified by such ordinance, would produce a material that will not only fulfill all the requirements of all sections of the ordinance, but the manufacturer himself would be guilty of such a misuse and waste of good material as to be almost criminally culpable.

Concrete building blocks cannot be made too good; no fear of that. The fact that most blocks made and used have been so poor and undesirable, both as to quality and appearance, is what has caused the almost universal criticism against their use in the better class of buildings.

Certain fixed proportions of cement and aggregates, although specified in a city ordinance, if of a certain character and quality, as defined by the ordinance itself, will not, even when handled by a skillful workman in a conscientious manner, make a conercte that will pass the crushing tests provided by the same ordinance. On the other hand, a mixture of a very different proportion of cement and aggregates, having much less cement and more aggregates of suitable degree of fineness and coarseness, when handled by the same skilled workmen, in a like manner, will give a concrete capable of withstanding, without sign of fracture, twice the compressive resistance required by the ordinance.

To illustrate, let us use the results of tests made by Dycherhoff, the eminent German authority, being the average of many experiments. He states that a mixture of 1 cement and 4 sand stood a compression test of 1,053 lbs., per square inch. While a mixture of 1 cement, 4 sand and 8½ broken stone stood a test of 1,205 lbs. In the second mixture, there was but 1-3 as much cement as in the first, yet the concrete so made was 14 per cent stronger. The loss of compressive strength by the addition of 1 part sand to a base mixture of 1 cement and 2 sand is 1,383 lbs.; 1 cement and 4 sand, 1,053 lbs. This is an average loss of 536 lbs., compressive strength for the addition of each part of sand. Should this average loss be maintained, when we add 1 part more sand making the mixture 1 cement and 5 sand, the block would not fulfill the compressive tests required by every ordinance I have seen that calls for such a test. At the same time, these Dyckerhoff tests show that the addition of 3 parts of broken stone to the mixture of 1 cement and 2 sand, gives an increase of 622 lbs., (29 per cent), per square inch to the mixture; and the addition of 5 parts broken stone gives an increase of 262 lbs. (12 per cent) per square inch in strength. In all these tests, the net amount of cement remained constant. It is assumed that in all these tests, the best material and workmanship was employed. What would have been the results had poor material and inferior workmanship been used?

The ordinance enacted by the Philadelphia Common Council, it being by far the most comprehensive one that has come to my notice, and the one most widely copied and most frequently cited, makes no distinction between the use of a mixture of 1 cement and 5 sand, and that of 1 cement, 2 sand and 3 gravel. Another ordinance compels the use of 1 cement, 1½ sand and 2½ gravel or broken stone, from which requirement, no variation is permitted.

The Philadelphia ordinance has fifteen sections devoted to rules and regulations for building structures of concrete blocks; fifteen other sections are required to define the methods and manner of making tests of such blocks, and five sections additional to the obtaining of licenses or authority to engage in the manufacture of this material in that city. In this elaborate enactment it is provided that in a building but three stories in height, the first story shall have walls of a certain percentage of air space; while in a building of six stories high, the third story, that must sustain three stories above, can have eight per cent more air space than is allowed in the first story of the three story building that sustain but two stories, and those near the foundation, and less liable to shock or vibration.

The Philadelphia ordinance embraces 2,500 words. In contrast to that, is the ordinance of the City of Chicago. It contains 66 words. Being so short it should be concise and explicit. The writer has personally submitted the Chicago ordinance to a number of attorneys in the City of Chicago. Not one of those consulted could tell, in any degree, the meaning of the ordinance.

The importance of the Code of the City of Chicago may be inferred, when it is known that it required the time and ability of a number of committees, each being privileged to employ, and did employ, skilled experts in the various departments. Months of time were consumed in its compilation, and a great deal of money was expended. The Chicago Code, as published, is a book of 250 pages; under its authority, more than $80,000,000 were spent in the construction of buildings during 1905. These buildings represent a street frontage of 47 miles. The material that we are met here to discuss, and which we believe to be the best material for certain kinds of structures, was recognized, as to building blocks, to the extent of just 66 words out of 250 pages, and those 66 words, so chosen and jumbled that neither author, commissioner, layman nor lawyer could tell what they meant.

Being interested in the manufacture and use of concrete building blocks in the City of Chicago, the writer consulted the building commissioner of that city regarding their use. He it is that interprets all the sections of the Chicago Code, and determines whether a structure may, or may not be erected, and how, and of what materials.

This commissioner ruled that this special block, known as a two-piece block, did not, in any respect, comply with this ordinance, and he would not allow its use in the City of Chicago. His office had, as a matter of fact, approved its use in a building originally designed for two stories, the plans of which were subsequently changed, and provided for a basement and an attic, making in reality a three and a half story structure. This building was constructed and stands a monument to the beauty and strength of concrete building blocks. The uncertainty of this commissioner's ruling is shown by the further fact that he ruled the use of a one-piece block could be permitted in a stable structure, one-story high, only on condition that all the air space be filled in with concrete after the wall was laid up. The writer was told that the walls were erected, the air space filled, and the very object and purpose of the hollow block defeated.

The code provides no appeal from his rulings. However, the good people of Chicago really wanted to use some of these two-piece blocks in structures not provided for in this 66-word section of the Chicago Code, and they took the matter before the City Council and there obtained special permits for the use of these blocks in church structures, and now, from week to week, a number of churches constructed of these rejected building blocks, under special permits, are used in the worship of the Architect of the Universe.

The architects to whom was submitted the portion of the Chicago Code relating to the use of concrete, personally told the writer that the plain intent and their interpretation of this section did unquestionably permit the use of the building blocks that were rejected by the building commissioner. No appeal was possible from this arbitrary ruling of the commissioner, nor is there any provision made for the testing of any form of concrete building block in the City of Chicago.

The City of Cleveland, Ohio, last year enacted what has been referred to by many competent to judge as the most perfect

code of building laws yet devised. Under that code of 350 pages there has been constructed a magnificent public school building of concrete blocks, and the largest church of which the writer has any knowledge, that has been, or is being built of these blocks, is building, as well as flats, stores and other public buildings. The city architect of Cleveland specifies these concrete blocks for public buildings; the building commissioner and his deputies and inspectors approve of their use. Yet, within the last month, this Cleveland ordinance has been cited by the building commissioner of another city as his reason for refusing to permit the use of any concrete blocks in his city. Apparently so little is known of the value and use of concrete blocks that in this code of 350 pages that but fourteen lines are devoted to concrete blocks and their use. Manufacturers of brick at Cleveland burn an average of 1,000,000 brick a day throughout the year. That is one item our material will supplant.

Certain ordinances now in force prohibit the use of concrete blocks more than 9 or 10 inches in height, or width of course. The unfairness of this is apparent. In one building that is constructed entirely of concrete stone, as to all walls and partitions, and in the erection of which a saving of about $15,000 was effected, there are a number of thousand feet lineal measure of concrete stone blocks wider than 20 inches, many of them measuring five feet in length. In another building, the work of making the stone for which is well advanced, there will be in excess of 2,500 separate concrete blocks, the average weight of each of which will exceed 1,000 pounds.

One ordinance permits the use of blocks 14 days old; another one refuses sanction for any blocks less than 28 days old I have seen blocks placed in the walls in a house in Detroit that were but two days old and of so little strength that they had to be carried on the pallet and slid off the pallet into position in the wall, the mason stating that he would water and cure the blocks in the wall. On the other hand, I have seen other blocks but two days old, that were cured in high pressure steam, and so hard and firm that the masons when laying them in the wall would select a block thirty days old, cured in the usual way, to break for special openings, rather than attempt to break the steam-cured block only two days old. The two-day old block, high pressure steam cured, was a better block in every respect

than a thirty-day-old block, made of the same material, in like manner and of equal moisture in mix, cured in the usual manner.

Attempts have been made to place a heavy penalty on the use of these blocks by compelling the employment of an inspector at the expense of the manufacturer on every building during the entire period of its construction. This is a manifest discrimination and unjust.

The status of these regulations would be very different had the manufacturers of concrete blocks, in all or a majority of cases, made a really good block. The fact is, the average output has been so poor in quality that those in authority in the larger cities have been compelled in self-protection to try to make regulations so stringent that inferior material and workmanship would not comply with their requirements. In this attempt, not having exact knowledge of the subject, they have been led into many errors, and conditions have been named that are unwarranted by any just view of this question.

The truth is, the importance of this subject has not been grasped. Those of us that have given the matter some thought have failed to comprehend the needs and requirements of a business that has sprung into being and attained such proportions in so short a time. The experiments now being made by the committees of the different organizations will aid materially in determining what is right and fair to exact by those in authority in our city councils; and what standard must be conformed to by the manufacturers of concrete blocks of whatever make or pattern. When it is known what is a right and just standard, to which all concrete blocks must conform to permit of their use, the writer believes that their use cannot be restricted by ordinance in any city, so long as they comply with a safe practice. This material is suitable for use in buildings; it is the best material in many respects now in use, and the people of every community are entitled to its use. Whether they will generally adopt it and apply it to new uses will depend upon the integrity of the makers of the blocks and the care exercised in properly placing them in the walls, to the end that beauty, as well as strength, be secured.

The standard that must be adopted cannot be one that restricts the use of blocks of a certain age, nor made of a certain proportion of aggregates, without reference to what the aggre-

gates consist of, but it must relate to the quality of the product. In brick work no attempt is made to say that a brick shall be made of one certain kind of clay and not of another, nor of clay at all; nor yet of shale and clay, or even of sand. The brick requirement is one of strength and compactness. It should be so of concrete.

We must patiently wait until the receipt of the results of the tests now making; and in the meantime insist as far as we can that our standard of quality be so high that no just criticism can result; and when we know just what to ask and insist upon, a united effort should be made to secure uniform legislation throughout the length and breadth of this land, in order that all intending purchasers may have an intelligent conception of the demands of the business before a plant is constructed and the manufacture of concrete blocks begun.

The legislation must provide that no building commissioner, or other person, shall have the power to arbitrarily decide, without tests, whether a block may or may not be used. Nor can any stated dimension or form of block be adopted. The standard must be one of quality. Around that can be grouped all the safeguards that are fair, just and reasonable.

HAIR CRACKS, CRAZING OR MAP CRACKS ON CONCRETE SURFACES.

By Albert Moyer.

As an introduction to the subject to be discussed I do not think it would be amiss to say a word regarding what is popularly called artificial stone. Such introduction is more particularly appropriate for the reason that the strongest cement stone that can be made, and which more nearly resembles the natural product, unfortunately contains those qualities which, under the usual process of manufacturing cement stone, make the product more liable to those disfigurements which are best described as hair cracks or crazing. I would like to call your attention to the word "artificial stone." To my mind this word is objectionable; it does not describe and it is untrue. A piece of tin, stamped and painted to resemble stone, is artificial; papiermache, molded so as to imitate stone is artificial, but the product manufactured by the use of Portland cement, sand and the various stone aggregates, is not artificial; it is as much a natural stone as any product produced by nature. The difference lies largely in the process by which it is made. Cement stone is a natural stone manufactured along the lines of natural law, but by an artificial process; contains all the qualities, in fact all the chemical components and elements of most of the natural stones. It has been demonstrated that the best cement stone, in appearance, texture, strength and quality, is composed of crushed stone; what I mean by crushed stone is screenings or quarry tailings, obtained from a tough, hard natural stone, such as granite, marble, very hard crystalline limestone, etc. These screenings, or, as they are sometimes called, crusher dust, are used in sizes all of which will pass through a ¼-inch mesh, and graded in size from ¼-inch down to fine dust, the percentage of dust not to exceed 25 to 33 per cent, or in sufficient proportion to fill the voids. The principles involved in the use of crusher dust or screenings are as follows: If the screenings are of a hard rock and the per-

centage of dust is not in excess of the voids, the addition of a sufficient quantity of cement to coat each and every particle in the aggregate will give the whole a thorough, compact mass. The aggregate being graded in size from coarse to very fine and the whole mass mixed very wet, the density of the stone produced will be found to equal that of granite. The cement adheres to the particles of stone far better than to the polished surface of sand. Each particle of dust is in itself proportionately as strong as a boulder. Therefore, if the cement is as strong as the stone and the stone is as strong as the cement, every particle of stone being covered with cement, and the cement adhering to the stone, the whole mass will be of equal strength to that of neat cement.

Theories are very beautiful, but unless borne out by practice are of little value. I am, however, very glad to state that this theory has been borne out in practice many times, not only in the laboratory, but in actual work. Briquettes made of 2½ parts screenings to one part of high-grade Portland cement, no particle of this screening larger than ¼-inch and graded in size to fine dust, the percentage of fine dust being about 33 per cent, have been broken in a number of series immersed in water for two years' time. The tensile strength recorded ranges from 900 to 1,100 pounds per square inch, which is as strong as the strongest neat cement.

In the manufacture of cement stone the proportions as above are stronger than necessary to give the required factor of safety for commercial use. The stone above described can be made in almost any form of mold. There are some forms of molds which give better texture to the surface than others; but the strength of the stone depends, not so much on the mold as it does on the careful mixing of good aggregate with high-grade Portland cement in proper proportions, the whole to be mixed very wet. As a suggestion, the writer believes that the future prosperity of the manufacture of cement stone depends on the invention of a machine which will produce blocks of various sizes hollow or otherwise, from a concrete mortar which has been mixed wet. In no other manner can complete and ultimate crystallization of the Portland cement take place.

We now come to the subject of those objectionable features, the disfigurements of the surface, which are particularly noticed

in very wet concrete. The appearance of hair-cracks or crazing on cement stone or concrete surfaces is a disfigurement, the cause and remedy for which has not received the study that so important a subject justifies. The cause of the trouble has been investigated from time to time, but heretofore the conclusions drawn have been very incomplete. Hair-cracks, being entirely on the surface, do not indicate a weakness in the cement stone or concrete. In most instances they are not greater in depth or width than that of a hair, at times they are not visible to the naked eye, and only become visible when exposed to the elements. The heat of day, the cold of night, frost in winter, the action of the rays of the sun, heating and then cooling the surface, widen the invisible cracks until they become a disfigurement. Often these cracks do not appear for several weeks or months.

It often requires investigation as to cause, to arrive at a correct solution of the trouble and thus apply permanent remedy; otherwise we would simply be dealing with symptoms.

Research conducted along theoretical lines seldom brings practical results, therefore the writer will endeavor to eliminate theory as far as possible. My investigation is founded on the reverse practice; that of noting and observing very carefully the practical results, both as to effect and remedy, and then endeavoring to explain these conclusions by theory.

It has been known for some time that very wet concrete is more apt to craze and show these undesirable hair-cracks than dry concrete. Dry concrete is objectionable from the standpoint of strength and density, and, therefore, its use cannot be advocated simply because hair-cracks are to some extent avoided. Investigation and practical demonstration leave no doubt of the fact that in wet concrete a portion of the flour or very finest particles of the cement is carried to the surface by the action of the excess water which is being absorbed by the atmosphere. This excess water is to a great extent drawn from the interior of the concrete to the exterior, carrying with it the finer particles, which, being deposited on the surface, form a richer mortar than is contained in the body of the concrete. Under certain conditions these fine particles deposited on the surface practically form a coating of neat cement.

Neat cement or the richer mortars are found to be much more liable to crazing than mortars containing a larger proportion of

sand or finely crushed stone. This is particularly true in the manufacture of cement stone by the use of sand molds in which the mixture is poured very wet. It has also been noted that, when the stone is properly seasoned by keeping the surface covered with a thick layer of very wet sand, or when the stone is immersed entirely and for some time in water, the trouble has been overcome almost entirely.

The crazing of neat cement is apparent in test pats for laboratory purposes, when these pats are exposed and allowed to set and harden in air. But if they are protected in a moist closet and afterward immersed in water for a period of at least twenty-eight days no hair cracks or crazing will result.

A careful examination of these cracks leads to the conclusion that they are due entirely to a contraction of the surface, the same contraction not taking place in the body of the concrete.

Experiments made by Prof. Swain and Prof. Bauschinger demonstrate that neat cement, when set and hardened in air, contracts. This applies to all brands of high grade Portland cements. Further tests demonstrate that this contraction increases with age up to a certain period. The same authorities demonstrate that a mortar made of one part Portland cement and three parts sand, hardened in air, shows contraction, but less in proportion than the neat cement.

I will now describe the results obtained by investigations made by the same authorities and others showing the effects of neat cement and mortar when hardened under water. The test pats or cubes of neat cement and mortar after the final set were immersed and kept under water for a considerable period of time. The results prove that neat cement when hardened under water shows a slight expansion, while mortar composed of one part Portland cement and three parts sand shows an expansion, but less in proportion than the neat cement.

Reducing these conclusions to figures and taking the average results obtained by various authorities, figuring the expansion and contraction in percentage, I find the following results:

Neat Portland cement hardened in air at the end of sixteen weeks shows a 15 per cent contraction.

One to three mortar hardened in air at the end of sixteen weeks shows a 5 per cent contraction.

Neat Portland cement hardened under water at the end of

sixteen weeks shows an expansion of 15 per cent.

Without going further into the matter of figures, it is safe to state that the expansion and contraction is less for shorter periods than sixteen weeks, and that the percentage will be a trifle greater if carried beyond sixteen weeks or up to six months, or a year.

We can, therefore, conclude that in a rich mortar there is more neat Portland cement on the face; and, therefore, a greater percentage of contraction of the surface; also that a less rich mortar will show a less percentage of contraction, and that if the concrete were kept wet and protected (which is equivalent to hardening under water), hair cracks and crazing would be avoided.

In the past this trouble has been partially overcome by brushing off the surface of the concrete or cement stone with a stiff steel brush, or by scrubbing the surface with a cement brick and wet sand, thus partially removing what might be termed a neat cement face. It has been found, however, that this does not entirely overcome the trouble, the remedy proving but temporary, the cracks appearing several months afterward. The brushing or scrubbing is merely an assistance; the real remedy lies in keeping the surface thoroughly and continuously wet as long as possible. It is unfortunate that this rule is seldom observed, and that in its non-observance good results are sometimes obtained. The worker in cement is thus influenced to disregard a matter of considerable importance in concrete construction. That good results are obtained from a disregard of these principles is largely a matter of luck. If the weather be damp for a number of days after the concrete has set, the object has been partially brought about by nature; then, again, the suface may have been so placed as to escape exposure from the wind or sun, which would tend to dry it, and was kept wet by the excess of water in the concrete.

The only permanent remedy which will eliminate entirely these objectionable features is the removal of as much of this excess of neat cement collected on the surface as is possible as soon as the molds are taken down. It is desirable to have the surface of the concrete or cement stone as near the same texture as the body of the concrete. The exterior should then be kept continuously wet by the application of water, sand sprinkled with water, or hanging wet cloths over the perpendicular surfaces,

keeping the exterior wet and the cloths wet by sprinkling or by any other method which will accomplish this result and supply similar or same conditions as when hardened under water. By so doing, not only is crazing avoided, but a stronger, tougher and harder concrete is obtained.

It is reasonable to conclude that if so treated the surface will slightly expand, but not to a greater extent than the body of the concrete which is already wet.

It is not amiss to bring this whole subject as prominently as possible before those having charge of concrete construction, endeavoring to impress upon them the necessity of keeping concrete protected and thoroughly and continuously wet for as long a period as economy will permit.

REPORT OF COMMITTEE ON FIREPROOFING AND INSURANCE.

E. T. Cairns.

The appointment of this committee only three months ago was so recent that there has been no time for organized research or experiments on an extended scale, but the views of individual members of the committee, based on their personal experience and investigation, are combined in the following report, which is presented as an outline of the most important work done on the subject up to this date, and acknowledgment is made at the same time that the subject is very imperfectly covered and that the members of the committee have much to learn regarding the fireproof qualities of cement. Indeed, there is such a scarcity of reliable data and so little actual experience with fires in buildings of any form of concrete construction, that, at the present time, any discussion of the subject must of necessity be largely on a theoretical basis, or, at the best, on the basis of laboratory experiment, both of which, while valuable and necessary, must be supported by actual field experience before the subject can be regarded as properly covered.

In considering the so-called fireproof qualities of cement or concrete, it will be well to fix in our minds at the outset the proper definition of the word "Fireproof." In a technical sense there is, of course, no such thing as a strictly fireproof building—that is, a building which is absolutely proof against damage by fire; there are, however, many materials which are non-inflammable and capable of resisting or retarding a fire of ordinary intensity for a sufficient length of time to allow the extinguishment of the fire with nominal damage to the structure. Therefore a building properly constructed of such materials may be entitled to the nominal term, fireproof; though, as a matter of fact, the strictly correct term would be fire resistive. Whether it is practical at this late day to make any such grammatical distinction of terms is doubtful, so that, perhaps, it will be as well for us to recognize the old term, "fireproof," notwithstanding its faults and the fact that in the past it has been the occasion of

some misunderstanding and the cause of an over-confidence which has cost many a building owner dearly.

By cement in fireproof construction, of course, we mean, generally, the Portland cement, which forms the vital element in monolithic concrete, either plain or reinforced, or concrete block construction, and since cement is always used in connection with the other materials making up concrete of some sort, we may as well use the term concrete construction, in place of cement construction.

That good concrete is a fireproof material in the above defined sense is a well-established fact, as has been demonstrated in a limited way by tests in laboratory and field. Most of the laboratory trials have been made with small buildings, 10 to 15 feet square, heated to 1700 or 1800 degrees with wood or gas fires for two or three hours' time—a test which, while not calculated to demonstrate the ultimate fire resistance, is thought to approximate the ordinarily severe fire which may be expected in most kinds of buildings; good concrete has successfully passed these tests, and the occasional failure of poor material under the same trial has taught some valuable lessons.

The field experience is more difficult to summarize. The first case in mind is generally the great Baltimore fire, in which were several small buildings involving more or less concrete construction, all of which came through the fire very well, though the conditions were somewhat favorable, in that the fire in each individual building was of short duration and no water was played on the building while hot. The Iroquois Theater fire, in Chicago, was another case of a concrete building suffering very little damage, but in this case, also, the fire was of very short duration and the test, therefore, very mild. The Pacific Coast Borax Company, in Bayonne, N. J., suffered a severe fire about four years ago in a building all of concrete except the wooden roof. In this case the test was very severe in the upper part of the structure, and the damage to the concrete very trifling—a good test with remarkably good results. Other fires of less prominence have occurred with similar results.

Considering first reinforced concrete: In order to be fireproof in the accepted sense the concrete itself must possess two important qualities, viz., 1st, it must be capable of withstanding such disintegration or breaking as would either diminish its own

strength or expose to fire the steel reinforcement; and, 2nd, it must effectually insulate the imbedded steel reinforcement from the heat of a fire, even when not broken down.

There are several factors affecting the first of these requirements; the stone or other aggregate must not lose its strength, or break or fly in pieces readily. In this particular there is doubtless some difference between the various aggregates commonly used, though we have only a limited amount of data bearing on this point. The National Fire Protection Association's Committee on Cement for Building Construction conducted a series of experiments a few months ago which afforded a comparison between limestone, gravel which contained a considerable proportion of lime, granite and cinders. These tests showed practically no breaking or spalling of the concrete, but the conditions were favorable to such result in that the samples were rather small and were so arranged in the test furnace that throughout the test they were free to expand in all directions, and the individual stones of the aggregate were of small size, not larger than ¾-inch. Analysis of numerous tests by the New York Building Department, the British Fire Prevention Bureau, and other sources, also fails to reveal any decisive difference of fire resistance of various concretes due to difference in the kind of aggregates in common use. The latest test of this which has come to our notice was made last October by the British Fire Prevention Bureau, which included simultaneous trial of seven small slabs of 1-2-3 concrete of different aggregates, described as slag, broken brick, coke breeze, furnace clinker, granite, burnt ballast and Thames ballast. the relative efficiency from high to low being about in the order named. Two of these, furnace clinker and Thames ballast, were quite deficient, but the others did not differ widely, and the result was similar to that obtained in many other tests; that is, some small cracks developed, and in some cases the material was washed off by hose-streams to a depth of an inch or so, but none of the slabs broke down.

It is the opinion of many that granite or any stone containing a relatively large percentage of water crystals is most objectionable, as it has a tendency to burst as the crystals are decomposed, this danger being obviously greatest where the individual stones are of a large size, and the use of such stones in concrete is, therefore, objectionable.

Limestone has been criticised as an aggregate on the ground that it is calcined or reduced to powder quickly under high temperature. It is true that it does lose its strength this way more easily than most other stones,, but this committee are of the opinion that the stone does not so weaken much, if any, before the cement which binds the units together, so its weakness is not really such an important matter as might at first appear. It is probable that trap rock, a hard, dense stone found in some Eastern States, or silicious gravel, or strictly clean clinker, make the most desirable aggregate from the fireproof viewpoint, though the latter being practically unobtainable in sufficient quantities makes a recommendation for its general use unwise.

The kind of sand, or its state of purity or sharpness, is thought to affect the fireproof qualities of concrete only as it affects the normal strength of the material and, therefore, the factor of safety upon which the endurance of the structure under fire largely depends.

It is very evident, of course, that the integrity of concrete under exposure to fire, as well as under normal conditions, depends primarily on the cement which binds the mass together, and in this fact lies the most important inherent weakness of concrete as a fireproof material. As to the fireproof qualities of Portland cement itself very little data appear to be available. The standard specifications adopted by the American Society for Testing Materials, the American Society of Civil Engineers and others do not touch on the point at all, possibly for the reason that some have assumed that cement which meets the other requirements as to strength, soundness, etc., cannot vary much in fire resistance, and perhaps for the reason that a very large part of the cement for which these specifications are prepared is used in bridges, embankments, marine work, etc., where fire resistance is not a factor. Neither do the United States Army engineers, nor various foreign specifications, cover the point, probably for the same reasons. Cements which conform to the standards above referred to cannot vary much in the proportion of their chief constituents, though some of the minor elements do vary considerably, and it is well known that there is quite a difference between various brands as to the quantity of water required for hydration, and it may be these differences, especially the latter may have an important bearing on the fire resistance. Various experiments now

under way will doubtless settle the question within the next year or two, but for the present we must assume that all Portland cements conforming to the accepted standards in other respects are of equal fire resistance.

The statement so often made that cement is necessarily fireproof because in the course of its manufacture it has been burned in a kiln hotter than any burning building is not true any more than is the same statement concerning hollow tile or other materials. They both appear in a building under radically different conditions than obtain in any sort of a kiln, the important difference in the case of the cement being that when mixed into a concrete it is combined in a crystalline form with water, which is a material very easily affected by heat. There is no occasion for discussing here the intricate question of the chemistry of cement. It is sufficient to say that the effect of heat is to dehydrate it or separate the water from the cement and thus reduce it to a condition resembling its original powdered state. The temperature at which this dehydration occurs is probably about 1000 degrees F.—that is, the cement itself must reach that temperature, but concrete, being a slow conductor of heat, any considerable mass of the material cannot absorb that amount of heat for some time after the temperature at its surface has reached the 1000 degrees or even a much higher point; hence it is that in a burning building a temperature of 1000 to 2000 degrees may be applied suddenly to the surface of a concrete wall or floor, and the result will be an immediate dehydration of only a very thin film of cement at the surface and a very slow progression of dehydration into the interior of the mass. As above stated, this dehydrated or re-calcined material does not necessarily fall away, unless struck by a stream of water or other object, or unless the rupture of individual stones in the concrete throws it off, and so long as it remains in place it acts as a very efficient insulator for the remaining good concrete beneath, so that the penetration of heat into the mass and its consequent dehydration grows slower and slower. If by this process the cement loses its adhesive strength, of course, the concrete is ruined, and, in the case of walls or columns, its crushing strength is reduced in the proportion that the dehydration of the cement has penetrated from the surface, and this is irrespective of the kind of aggregate used. The logical conclusion of the above is that, given a cement and aggregate of good quality, the fire re-

sistance of a concrete wall or floor is entirely a question of the time of exposure and temperature of the fire.

Whatever the comparative value of various aggregates or cements may be, a far more important factor in the strength of concrete under fire, as well as under normal conditions, is the relative proportion of the materials and the method of combining them. The necessity of a dense, fairly rich concrete, practically free of voids, such as is produced by a wet mixture well tamped, is well known to all experienced users of the material, and the troubles occasioned by mixtures containing too little cement, or made too dry, or not properly tamped, are perhaps too familiar to some of us. This feature has a direct bearing on the fire resistance of the structure, as a dense, rich mixture is much less liable to spalling and disintegration than a poor, porous concrete; and if the theory is correct that the dehydrataion of the cement itself or the driving off of its water is what weakens the mass, then the richer in cement the mixture is, and consequently the more water is contained in the mass, the longer the cement will last, because a longer time will be required to drive off the large amount of water. Furthermore, its factor of safety above the strength required for normal conditions is naturally much greater, and that has a most important bearing on the fire resistance feature; a structure so built that a considerable proportion of its ultimate strength may be destroyed by fire without causing a collapse, obviously has a much greater chance of escaping total loss than one which, though noninflammable, has no great strength above that required for normal conditions, and so would be subject to collapse on the failure of some one or two of its vital members. The abnormal strains to which a building is subject during a fire are always severe and often not to be determined in advance; the falling of heavy weights and internal stresses set up by rapid changes of temperature are severe trials to any building, and the structure that contains the greatest reserve strength above that required for ordinary demands is the safest.

This, of course, refers to any type of construction as well as to concrete, and the disregard of this principle has in many cases cost dearly in the case of a fire. In the famous Baltimore conflagration, the great weakness of tile and steel construction was along this very line; the tile was good enough for its normal uses, but was generally too thin and frail and too poorly secured in place

to withstand the mechanical strains imposed by a severe fire.

As to the second general requirement of insulating quality of concrete for the steel reinforcement, the importance of this function of the material is apparent when we remember that in practically all reinforced concrete construction the steel, of whatever style or system, is designed for the vital duty of carrying all the tensile strains of the structure, and in order to do this it must be placed as low as possible in the beam or slab; in fact, there is no reason, structurally, for more than barely covering the rods. It is well known that steel loses its strength very rapidly on exposure to fire, and steel of any form used as a reinforcement for concrete is no exception to the rule. According to "Kent," the tensile strength of steel at 670 degrees is only 75 per cent of its ultimate strength under normal temperature; at 725 degrees, 60 per cent; at 770 degrees, 50 per cent; at 860 degrees, 40 per cent; at 1025 degrees, 30 per cent; from which it is obvious that the reinforcement of a concrete floor beam, slab, column or wall must have some very efficient insulating material between it and an ordinary fire if its strength is to be retained. It is well known that concrete is a very slow conductor of heat, but there is little exact data on the subject. The tests of the National Fire Protection Association Committee, above referred to, were chiefly for the purpose of determining that point, and showed that on an average eleven sample rods, embedded to a depth of one inch in concrete, reached a temperature of 670 degrees, where their strength is reduced 25 per cent in fifty-nine minutes under average temperature of about 1500 degrees at the surface of the samples.

This would appear to afford ample proof that one inch of concrete covering over steel reinforcement, or about steel I-beams, is not sufficient for reliable fire protection. In many large buildings, particularly of mercantile or storage occupancy, temperatures of 1800 to 2000 degrees may prevail in portions of the structure much more than an hour, in which case 2 inches or more of protection would be necessary to preserve sufficient strength in the steel to carry its load. This would be true, even if all the concrete were certain to remain in place during a fire, and with the possibility of some of the material breaking off, the extra thickness is doubly necessary. As to the relative value of the various kinds of aggregate as an insulator, none of the numerous tests referred to indicate a very wide difference, but such variation as

does appear is in favor of the cinder aggregate and most unfavorable to the granite. Here, again, the superiority of a rich, dense concrete appears, as the tests indicate that as between rich, medium and lean mixtures the richer mixtures were appreciably slower conductors of heat than lean ones.

The fire resistance of concrete blocks for wall construction has been the subject of much anxious inquiry for some months past. The question is being investigated by several interests, but probably most exhaustively at the Structural Materials Testing Laboratory of St. Louis by your President, Mr. Richard L. Humphrey, under the auspices of a General Advisory Board, composed of representatives of a large number of engineering bodies, including this association, and government officials. The result of this and other investigations, of course, cannot be foretold by this committee, and the actual field experience with this construction thus far is too limited to afford a basis for positive conclusions. However, we are confident that most of the foregoing statements on the subject of concrete in general are applicable to small blocks of the same materials. The form in which most of these small blocks are made involves a certain weakness under severe temperature which, while by no means fatal to the fire resistance, places a limitation on that quality which must be recognized, viz.: It is subject to breakage by unequal expansion under heat, the same as is hollow tile or any other similar hollow material. Hollow blocks of concrete or tile, as set in the walls or floors of a building, usually present only one surface to the direct attack of fire, and the consequence is that that side or face of the block expands readily and irresistibly under the influence of the heat, while the other three sides, receiving much less heat, do not expand nearly as rapidly, with the result that the hottest side breaks away from the others. This has been demonstrated in actual fires and experimental tests for both concrete and tile. Failure from this cause would naturally occur soonest in blocks having a thin shell, inasmuch as the thinner the shell of the block toward the fire the more quickly it will heat through and consequently expand. Therefore, if you would have a block stand a hot fire, make the webs thick.

This breaking by unequal expansion has sometimes been referred to as a bursting due to pressure of steam or gases generated in the large hollow space or cell of the block, but a very brief analysis of the conditions will easily disprove any such statement.

In the first place there is generally no means of getting water into the interior of a block and no probability of gases from other sources being introduced therein, but if it were possible to get gas or steam into the interior space, these cells are so continuous in a wall or floor and have so many vents to the atmosphere at the top of the wall or through mortar joints that the accumulation of the number of pounds' pressure (estimated at 25 to 50 pounds) necessary to burst an ordinary small block would be an impossibility under working conditions. In connection with blocks, we may repeat that, as in the case of monolithic concrete, good materials, plenty of cement, careful curing and, above all, intelligent workmanship, produce the most fireproof result.

To sum up this matter of the fire resistance of concrete, we may repeat that, while, like all other building materials, it has its limitations, it occupies and will continue to occupy an increasingly important position in the field of fire resistive construction, and when intelligently used under proper conditions may be relied on to resist such fires as any ordinary building may be expected to experience. Such intelligent use will involve the selection of good materials, will provide for the correct and uniform proportioning of them, the thorough mixing by good machinery, adequate thickness of insulation of steel, guarding against freezing, and, in the case of blocks, proper curing and thickness of shell; in short, all the requisites of a building safe and strong under normal conditions with a liberal factor of safety. It may be safely assumed that concrete, which is the richest, strongest and most durable under normal conditions will develop the highest fire resistance.

The relation of fire insurance to concrete construction is important to insurance companies and builders alike. The attitude of the companies toward concrete up to this time has been, like that of other interests, necessarily one of inquiry and investigation largely. They have felt that this type of construction was in an experimental stage, acknowledged as peculiarly subject to abuse by incompetent users, and have naturally been somewhat cautious in indorsing it as fully as its advocates would like. They are now recognizing, however, that the matter is rapidly approaching a settled and known basis in the building world, and they are at the present time according it more recognition in their underwriting than ever before. Insurance companies are the most earnest advocates of improved construction and are constantly urging the

adoption of the best known methods and materials for building. They are investigating the whole concrete subject through the National Fire Protection Association and other channels, and there need be no doubt that concrete construction will be given full credit in fire insurance rates and classifications for all its good qualities as soon as its record is established. In the meantime they are giving very liberal credit to so-called fireproof buildings of concrete construction, practically the same as are allowed for other types as a rule. They are not, however, recognizing concrete blocks as the equivalent of good brick, for the reason that such experience as they have had in labortory and field does not warrant it. This is no doubt due partly, if not chiefly, to the fact, familiar to us all, that a large proportion of the blocks made up to this time have been of an inferior grade, made without due regard to the known requirements of a good product; and in the matter of insurance rates, as in other respects, good material has been made to suffer for the failings of the too large proportion of poor.

In closing, we cannot too strongly emphasize the fact that the position concrete is to occupy in the art of fireproof construction will depend very largely on the degree of intelligence and honesty of its users. It has had something of a fight to attain its present position. It is not a new proposition. For years it has been known, and for as many years has been criticised as being peculiarly subject to abuse by incompetent contractors, a criticism which we must admit is altogether too well founded, and for which some of its most ardent advocates are partly responsible. There will always be more or less such criticism, but it can be largely overcome and the art maintained on a sound basis by the intelligent and persistent following of sound engineering principles and good workmanship on the part of its advocates.

The time has not yet arrived for adopting a detailed standard for fireproof concrete construction, but we would commend to you a few fundamental principles which were laid down by the National Fire Protection Association in their last report as essential to the best results, viz.:

1st. The work should invariably be designed and its entire erection supervised personally by engineers of skill and experience in this particular line.

2nd. Concrete for fireproof construction should be composed

of highgrade tested Portland cement, clean sand, and broken stone, gravel, slag or cinders, so proportioned that the cement will completely fill all the voids in the sand, and the mortar thus formed will a little more than fill the void in the aggregate.

3rd. The materials should be well mixed by machine with enough water to make a distinctly "wet mixture" and should be tamped down so that no voids are left.

4th. All steel members of whatever style should be imbedded at least two inches in the concrete, and in the case of important load-carrying members, three inches.

5th. No cement work of any kind should be laid in cold weather without being safely guarded against freezing.

DISCUSSION.

Mr. Watson: I would like to ask Mr. Cairns what minimum thickness of a block or shell of a building block is necessary for fire proofing.

Mr. Cairns: I have no better basis than a pure gas test for that matter. The only test I know of was one which I made some months ago of some blocks which were admittedly poor, and in that case two hours of fire, 1500 or 1600 degrees Fahrenheit, penetrated and spoiled the concrete utterly to the depth of two or three inches. That was on all of four different preparations or mixtures, 1 to 3, 1 to 5, 1 to 7 and 1 to 9 cement and torpedo sand.

Mr. Miller: In the form of a building block?

Mr. Cairns: Hollow concret block. I would think on good blocks it ought not to penetrate as deeply as that. I think that anything less than 2 inches should not be tolerated, and I am inclined to think that 2 1-2 inches would be much better.

I intended to say before that I would personally and for my committee very much appreciate it if any of you gentlemen would send us any information that comes to your notice regarding actual fires in buildings anywhere of concrete construction of any sort. We need all the information we can get, as it is harder to obtain fire resisting qualities than strength or durability, etc.

Mr. Miller: If I understand Mr. Cairns correctly, he said

he did not think there was much difference in fire resisting character of different aggregates. Now, our experience in the New York Building Bureau, I think, leads us to different results. I recall especially a test which was made in the Butterick building in New York, where, after the building was practically completed, a furnace was built on one of the upper stories, and a fire maintained in it. It was built so as to come right under the center of a concrete floor, running through the center of which was one of the large supporting girders of the floor, which had been protected by slabs of cinder concrete 1 1-4 in. in thickness.

This cinder concrete had been prepared by using ground cinders mixed in the proportion of 1 of Portland cement to 2 of sand and 5 of cinders, and made up in the form of plates, which were attached to the lower side of this girder. Fire was maintained in the furnace continuously, the temperature maintained being 1700 degrees, on the average taken by pyrometer readings, just below the lower side of this girder. The girder was composed of two steel beams side by side, so that from above we could reach down and read the temperature on the upper side of the slab. The temperature there did not exceed, as I recall it now, 300 degrees. These fire tests are made on full size construction, generally in brick buildings, with a fire maintained for four hours at a temperature of 1700 degrees Fahrenheit, the construction being loaded at the same time with 150 pounds per square foot. We have made, since that work was started in 1896, sixty-three different tests. Of these fourteen were on stone concrete, five resulting in a total failure. Now, when I say a total failure I mean more than simply the cracking of the concrete. We regard them as successful when the fire does not pass through the floor or the load does not cause the floor to break. But in these five cases there was an actual collapse of the concrete, or so nearly so that it was considered dangerous to continue. In one instance that I recall now in particular, where there was not actual failure of the slab, yet an exposure of the steel reinforcement, the steel did not show any real deterioration or drawing out on account of excessive heating; but of the 36 cinder concrete constructions there were only five failures, showing a very much smaller proportion. I do not mean to say that these concretes are not fireproof. What I mean to bring out is that there are certain conditions which are conducive to fire,

and we must find out what those conditions are, and we must guard against them. Now, in one of these cinder concrete floors it was simply due to the reinforcement being too close to the bottom.

After the floor had been subjected to this test the concrete had broken in two, and we could readily see that the reinforcement had been drawn out, due to being heated and having lost its strength. Outside of these, we made three tests on block concrete, one of which proved a failure, but not on account of the character of the concrete. The failure was due to the fact that there was a defect in the steel reinforcement. There were eight tests on terra cotta construction, one of which was a failure, but the failure in that case was due, in my opinion, to badly designed construction. There were two tests, one being on a plastic composition; the other I don't recall, both of which were successful.

Mr. H. B. Stephens: I notice a great many people are using crushed rock in their blocks. To say as a general proposition that crushed rock is good material, without specifying the kind of rock and the conditions under which it will be used, is a mistake, especially if the rock be common limestone and there is a possibility of its being exposed to fire. In that case you had better use all sand. In one case in Cincinnati, on Vine street, we made a fire test which showed that if you get any lime rock whatever in your block it is bound to slack. You all know, I presume, that with a first-class bank sand and cement it takes a great deal of heat and a considerable amount of water to have any effect; but if you have any stone dust of a lime-maker in your block, it will show when it comes to a bad fire.

Mr. William S. Hotchkiss: I want to take an exception to the gentleman that just spoke regarding the fireproof qualities of a limestone. On April 27th, 1905, we built in Chicago a flue for a brass and furnace firm. It has been subjected to from 3200 degrees to 4500 degrees of heat during the day and has been allowed to cool at night, and has been absolutely cold from Saturday noon, when it cooled off, until Monday morning; so that when they started their fires on Monday morning the flue would be cold. That has opened up only one very small crack, and that was due to some weight that was put on at a point at which the thickness of the block where the weight cen-

tered was not sufficient to hold it. We have found that using limestone has saved a great deal of money over what it would have been necessary to expend in fire brick. The stone we used is the same stone that is burned by the Chicago Union Lime Works.

President Humphrey: I would like to ask the gentleman a question about his furnace. Was there any slagging action which could protect the furnace?

Mr. Hotchkiss: There was no lining at all. It is an annealing furnace.

President Humphrey: Did any water ever come in contact with the surface of the furance?

Mr. Hotchkiss: Yes, but there has been no deterioration apparent.

President Humphrey: I would like to answer the gentleman who spoke of the effect of heat on limestone. The carbonic acid gas is driven off at a temperature of 1700 degrees and upwards of Fahrenheit. The rate at which that is driven off is comparatively slow, for the reason that one of the strong points of concrete is its very low conductivity as regards heat. While it might be true that the outside particles of that material are decarbonated by that heat, the slow penetration of heat into the interior would not liberate the carbonic acid of the particles some depths from the surface. The action upon a block submitted in a fire chamber is that the carbonic acid gas is driven off. There are all kinds of limestones. Limestone which is of the magnesium type, that burns with a considerable amount of core, that is inert material, gives very little pure lime. Now a material of that kind will stand the attack of heat much better than a pure carbonate which will burn down to a white lime. Even gravels may differ greatly as to fire resisting qualities, and the mere statement that the material is a gravel conveys no information, unless accompanied by the statement that it is silicious or mixed with hard pebbles and limestone. Our experience in the investigation of the gravels of this country showed that a great many gravel formations were tailings of glacial moraines and contained a considerable percentage of limestone. Just as soon as water is brought to bear on a surface of concrete composed of limestone or gravel containing limestone, which has been heated to a point where the carbonic acid gas

is driven off, the lime which exists there is oxidized, and is immediately liberated, and successive applications of water will wash that limestone away. It, however, takes a considerable quantity of water to sufficiently slack it so it runs or begins to show any possible disintegration.

Mr. Lesley: So far as the fireproof qualities of lime are concerned, as I understand the gentleman who spoke of brass furnaces, it was a flue which was constructed of concrete in which limestone formed a base. That was a case of the heat going over a level surface. Now, reverse that proposition and build a house and have your heat ascending against the limestone body. You have practically got in a house (an illustration, I think, I had to take once before) a limekiln. The stories of your skyscraper buildings, with limestone floors, are simply the layers of limestone in a limekiln. Your furniture, your storage, or whatever you have in this building, are simply the fuel that could be used in a kiln. Now light your kiln at the bottom, and you will produce lime without a doubt. Turn on water and you will produce slaked lime without question. The distinction I wanted to draw was the distinction between the flowing flame over a given surface, without penetration from beneath, and a flame which goes through the construction from the bottom upwards with a draft.

Mr. Hotchkiss: Mr. Lesley misunderstood me regarding this kiln. This kiln, or, rather, flue, is an oblong structure, in which there are six holes that allow the hoods of these furnaces to go in. The flame is directly against the one side of the flue, and this flue is constructed, as I said, of concrete blocks with limestone entirely as the aggregate. It is not flame flowing over a limestone surface. It is directed against the surface.

Mr. C. J. Farrar: While we are talking about limestone, I would like to know if any one here has had any experience with blast furnace slag sand?

Mr Cummings: Slag sand is the granulated slag made by blast furnaces, and is commonly used around Pittsburg and also for the manufacture of cement. Its fireproof qualities are equivalent to slag, and there is no question of its disintegration. It is fireproof material. It needs no demonstration of its fireproof qualities. It is practically indestructible. I have, as a matter of fact, used it in combination with common river sand, but

in ordinary structures slag sand is very desirable material. It is very light, weighs about two-thirds the weight of ordinary sand and makes very excellent rock. I happened to see some blocks made of slag sand by Mr. Peabody of Pittsburg, and I must say they produced a very satisfactory block. I saw some of them that had been exposed to the atmosphere for about a year without any apparent disintegration, and I think where they have been used they are very satisfactory. They are about two-thirds of the weight of an ordinary block and produce an equally fine surface. They are somewhat porous, but slag sand, in combination with Portland cement, makes a very good block for ordinary commercial purposes.

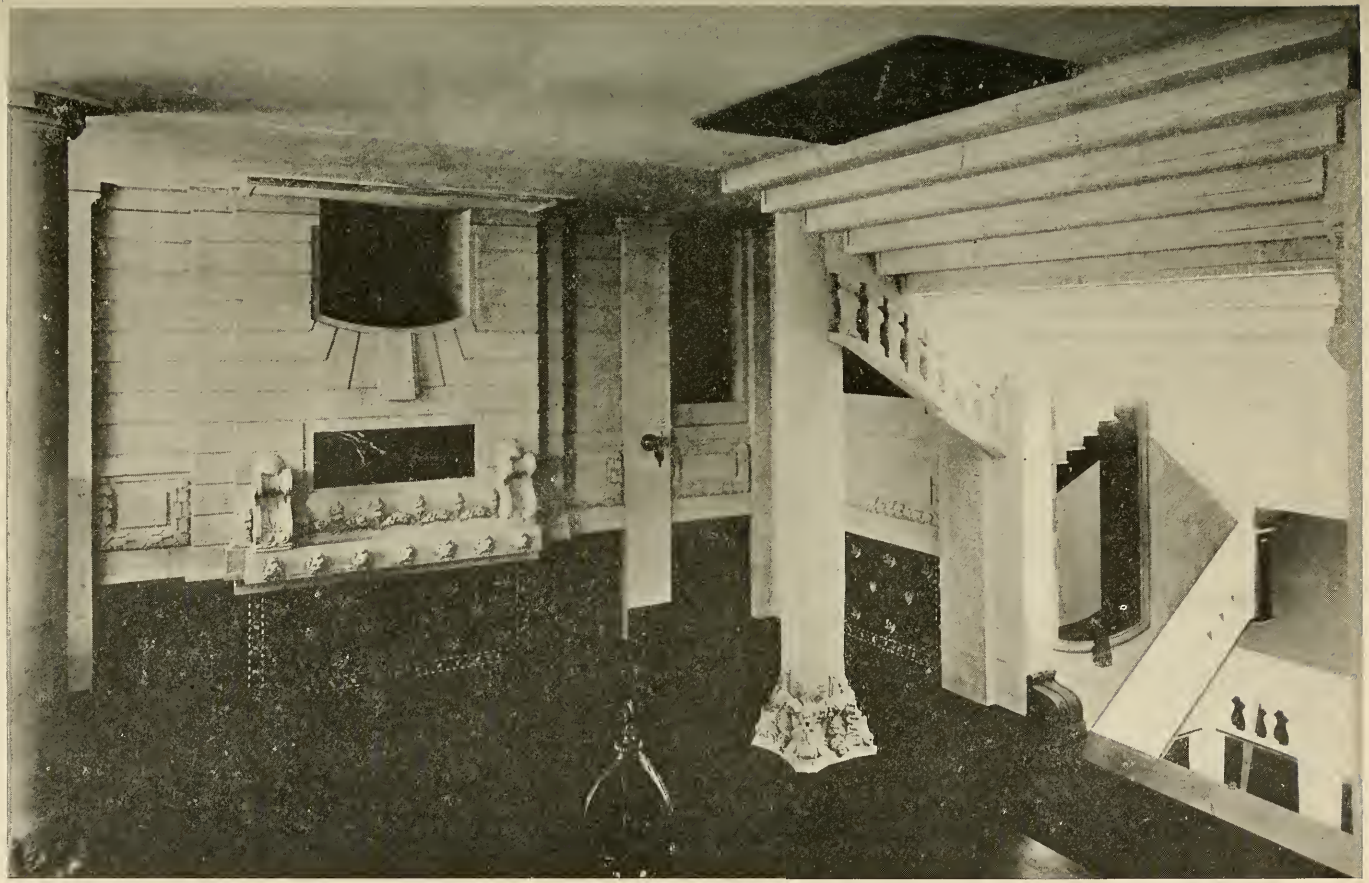
Mr. Watson: Mr. Miller stated in his paper that he noted a loss of 40 per cent in strength by freezing and thawing. I think he made no statement at what age the test was made. Will you give me that information?

Mr. Miller: I don't remember what the age of the specimen was. I know it was less than sixty days, because our inspector was present at the time the brick was made. They were cement brick the same size as our ordinary brick, about 2x4x8 inches. I might describe what our freezing test is. It consists in taking the specimen, a half brick, saturating it with water, placing it in a freezing mixture for at least twelve hours, removing it and immersing it in water of about 60 or 70 degrees, and repeating that operation about twenty times. Then, while the specimen is still wet, trying its compressive strength in the testing machine, and in this particular case an unusual condition was noted, which I have not noticed in any other test, either of block or sand lime brick. That was that at each successive immersion in the water the weight of the specimen would increase, showing that it continued to absorb water, although we had submerged it in water at the start so that it would no longer absorb water. That seemed to indicate that there was a separation or distention of the particles, and the loss in strength developed in that case was about 40 per cent. The resulting compressive strength, after freezing, was 2700 pounds, showing a very good result even at that.

REPORT OF THE COMMITTEE ON ART AND ARCHITECTURE.

CHARLES D. WATSON.

Progress in concrete construction during the past year has been most notable along the lines of improvements in its appearance, to enable it to be used for face work in the higher classes of buildings where good architectural effect is essential. For many years the unsatisfactory appearance of structures built of this material has prohibited its use for facing of high-class structures, and this difficulty in the use of a material which is otherwise superior to the majority of other materials used for a similar purpose, on account of its durability, has long been lamented by architects and engineers. It has only been during the past two years that much real progress has been made in devising means to improve its appearance and to do away with this objection. In the past the necessity of artistic and pleasing effects on concrete surfaces has not been so apparent, since the material was used only in masonry and other heavy construction, but with the growing demand for its use in the higher class of buildings this difficult problem is being forced to the front. Concrete structures like those built of the older and more common materials depend upon two factors for their artistic effect. First, design; second, execution. By far the most important of the two is the design, which lies almost entirely within the jurisdiction of the architect, while the execution, or we might say, finish, often depends a great deal upon the contractor or manufacturer. The artistic effects of concrete structures will, therefore, depend upon the co-operation of both architect and contractor. The former must realize that he is dealing with a comparatively new material, having its own characteristics, and to which he should give careful study. Instead of endeavoring to transform the material itself, he will do far better to adapt the material which has special characteristics to his needs. The tendency has been for designers to use concrete to imitate other materials, which seldom gives satisfactory results from an artistic point of view. Contractors should assist architects in their endeavors to give concrete an individaulity in design by giving them



their experience in its treatment, and by following out the architect's ideas as closely as possible, as to color and finish.

Buildings in which concrete is used for exterior finish are divided into two classes. First, those constructed with reinforced or monolithic walls, whose exterior surfaces require some kind of finishing. Second, those constructed of cement mortar or concrete blocks, either for trimming or for the whole surface. It is with the first class of structure that the greatest difficulty has arisen

to get an artistic and satisfactory appearance. Buildings built or trimmed with blocks are usually designed for stone or terra cotta, and the ultimate appearance of the structure will depend largely upon the manufacturer's ability successfully to imitate those materials. But the monolithic walls, whose exterior surface is exposed to view, is a comparatively new proposition for the ordinary designer, and one which has given him no end of trouble. The question has been how to overcome the dull appearance of large

surfaces built of cement, whose displeasing effect is often augmented by unsightly stains, discoloration and efflorescence. The different textures, colors and surface finish that can be obtained in this material require a most careful study and handling in design.

The different methods of improving the appearance of such structures are almost unlimited, but plastering the surface seems so

far to be the most common method employed, and, I might say, the most unsatisfactory, as regards appearance, not to mention durability. Many experiments are being made with different kinds of cement and stone to give the surfaces of such structures a more artistic effect, when plastered or painted; and notable improvements in both method and result have been made, but it is still an open question whether such methods of treating walls is a permanent improvement. The common practice of plastering and

blocking off to imitate stone is anything but satisfactory as regards architectural effect. The practice of finishing the surface by bush hammering or chiseling the surface seems to be the most satisfactory way of getting artistic effects, especially on certain classes of structures, such as bridges and other heavy construction, where the finished surface does not come directly beneath the eye.

Another method of finishing which appears to be equally successful is by the removal of the cement or mortar binder from the stone ingredients, by alternately washing the surface with acid

and water, or by washing out the cement with plain water while the same is in a green state. This latter method is being used to a considerable extent in the last few months with good results. By this method small and uniform particles of stone are mixed with the mortar facing, so that when the cement is removed it leaves a very uniform and pleasing finish, resembling granite in texture.

It is the second class of building—that is, in which cement stone blocks are used in whole or in part—that gives to the architect the wider scope in design and enables its use for the very highest

type of buildings. But even these have limitations, there being on the market as many kinds of cement stone, as there are of common brick. It is the duty of the architect to investigate and adapt his design for the particular kind of material which he proposes to use. He should not design for brick and substitute hollow building block; or for terra cotta and use manufactured stone.

Most of the architect's disappointments to date in the use of

cement stone, are due to the fact that he expects the material to replace some older building material, for which he has already drawn the design, and through the fact that he left the responsibility of the execution of the work entirely to the manufacturers. There are some manufacturers who have had sufficient experience to enable them to turn out a product which will entirely fulfill his requirements, but there is a vast majority of manufactured material that was never intended to take the place of cut stone, but which when properly treated, would give a very

artistic structure. A designer should select his quality of manufactured stone the same as he would select face brick, or the different varieties of cut stone. The quality and appearance of blocks made by different processes and intended for ornamental purposes are so varied that it is necessary for the architect to be familiar with the exact product that he intends to use in making his design. Concrete blocks, as they are made to-day, vary from specimens that resemble, and in fact are little superior to clay, to blocks that so closely resemble natural stone in both color, finish and texture, that it is impossible to detect the difference between them and stone. The different grades of block, like different brick, must all be handled differently. They all have their special characteristics, and their places in the structure, and the duty of adapting them to a design lies entirely with the architect.

Then, too, the architect will do well in many instances, to consult the manufacturer in regard to details of design, instead of requesting him to blindly follow those intended for other materials.

The writer has, in his experience as a manufacturer, met much difficulty in executing in cement stone details that were intended for wood and terra cotta. A successful design in manufactured stone ordinarily requires bold detail even more than is required for cut stone.

The development in the use of concrete blocks for ornamental building material is naturally greater in countries where there is a scarcity of building material, or where the expense of using this material is prohibitive. Germany and France seem to be far in advance of all other countries along this line, and ornamental cement stone is perhaps one of the most staple building materials of that country. Great progress has been made in America especially in the last few years. There is no question but that cement stone can be made superior to natural building stone, but it requires the combined assistance of architect, manufacturer and cement manufacturer to accomplish it. To the architect, we must leave the design; to the cement stone manufacturer, a development of the material in quality and appearance; and from the cement manufacturer must be obtained the assistance in providing the highest grade of cement that can be made for this purpose. The cement manufacturer will do well to

devote close attention to this growing industry, and he should recognize the necessity of manufacturing a grade of cement suitable for this trade. We need an absolutely nonstaining, light colored and perfectly sound cement. When the manufacturer gets these, his work of overcoming the other various difficulties of manufacture will be comparatively easy.

Engineers, architects and manufacturers must work together to standardize the processes of manufacture. The time is not far distant, when the profession will be testing cement stone, and when that time comes, the manufacturer must be in the position to live up to the specifications.

The development of concrete construction to enable it to be used for the facing of the highest class of architectural creations, is a problem vital to all interested in the growth of cement. It is the last obstacle in the path to a sweeping victory for this material. It has already proven its superiority over other building materials, as regards strength and durability. If to this we can add appearance, the battle is won. It was for the purpose of winning this battle, that this large and representative association has so wisely established a division of Art and Architecture.

As the Vice-President of that section, I take this opportunity to appeal to every man in this convention, whether he be engineer, architect, contractor, or manufacturer, to assist in this work by studying the problem of how to bring about more artistic concrete structures.

DISCUSSION.

F. H. Gill: What ingredients did you use for your concrete?

Mr. Watson: That is a point that I did not intend to go into now. The process of manufacture is a very intricate one, but I might say in answer to your question that we use nothing but the purest lime-stone and cement. We regrade our stone to four different sizes to fill the voids as closely as we can, and to make as dense a stone as possible. The grade varies from about the size of corn down to dust that will pass a thirty mesh screen. We have four different sizes.

President Humphrey: Do I understand that the caps were cast?

Mr. Watson: Yes, all of the caps were cast. My point there was this, that we take the architect's model—in all architertural work the architect will always furnish a model in clay—and we will take that very model, make from it a gelatine cast, and from that make a break-down mould from which to get a cast, so that the result is naturally a copy of a model approved and furnished by the architect.

President Humphrey: I understood you to say that they were hand carved.

Mr. Watson: Well, they are hand finished afterwards. We had some difficulty in shipping them at first, and we had a great deal of trouble with breakage. The percentage of breakage was perhaps as high as ten per cent, due to the fact that the average contractor did not know how to handle the work. We realized the difficulty at once, that everything depends upon the setting of the stone. It is very difficult to train a man to handle properly a cement stone. It has therefore become our universal practice not to sell our stones or ship them unless we can erect them ourselves. We are now training a force of men who thoroughly understand the work, and we will not take orders unless we can use our own setters. There is, of course, one advantage in cement stone, and that is, that it can be repaired, and that the repairing can be made very durable; but it is a very poor practice to advocate the repairing, because it is very apt to make the men careless and produce an inferior grade of workmanship

Mr. F. H. Gill: What is the weight of the stone?

Mr. Watson: The stone weighs, when dry, 129 pounds to the cubic foot. We have made experiments on absorption and we find that it is about 7, and with the lime stone that we are using it runs to about 6; but we are using a very hard limestone. The absorption of sand-stone would run as high as 15, so we are running considerably lower than sand-stone, but not quite as low as limestone.

Mr. F. H. Gill: Do you have any difficulty in Canada, Mr. Watson, in getting labor to lay this material?

Mr. Watson: Yes, that is a very sore point. We had no end of trouble when we first started. The bricklayer claimed that he must handle all of our material, and we could not see it that way. We stuck that it was the stone-cutters' business, but we infringed so greatly on the stone-cutter's trade, that through the action of the bosses, the Stone-Cutters' Union passed a resolution that they would have nothing to do with our work. That, of course, placed us in a ridiculous position. The bricklayers could not lay it and the stone-setter would not lay it.

We, therefore, had to train our own men, but thanks to the immigration into Canada last year, we have been able to secure some very able Scotchmen, and we are having good success with them.

J. P. English: Were they mechanics, or did you pick them up anywhere?

Mr. Watson: They were all mechanics; we are very careful in this particular. The caps were not cast in sand, but they were cast in what we call break-down moulds. It would be impossible to make sand stand up in such intricate designs.

F. H. Gill: Is the coloring matter which you use in the stone in the form of pigment?

Mr. Watson: Yes, it is pigment.

President Humphrey: How does the cost of this stone compare with that of cut-stone?

Mr. Watson: That is a difficult question to answer. It is like terra cotta; it depends on the character of the work itself.

President Humphrey: Generally speaking, would it be more or less?

Mr. Watson: In every case it is less. I don't know of any case where it is more.

MACHINERY FOR CEMENT USERS.

W. W. Benson.

The concrete building block industry has during the past four years advanced by leaps and bounds, chiefly owing to the aggressive efforts of the many manufacturers of concrete block machines and to the small amount of capital required to get into the business, and in consequence the subject of machinery for cement users has been chiefly confined to the various kinds of block machines. There is, however, a much greater field for machinery in connection with the industry. In a properly equipped concrete block plant economy must of necessity be the watchword. Thus, economy in management and production are alike necessary, in order to meet competition and leave a profit. Personally I have had occasion to visit many plants during the past year, and have found that those who had gone into the business along broad lines, with ample working capital, which enabled them to erect a proper plant containing a number of any of the standard block machines or systems, mixers, sand screens, cars, crushers, tampers, etc., and who combined with such an outfit lots of business energy and a thorough knowledge of the use of cement, were developing a good business, but we failed to see any occasion where a man with absolutely no knowledge of cement, but little capital, and a cheap mold of some kind, was doing either the business or himself any particular good. In such cases the only one to profit is the machine salesman and he only temporarily. Personally I do not believe that the one-machine plant can be made to pay under any circumstances where the product is merely manufactured and sold in competition with brick, unless the operator is a practical mechanic and cement worker and who is engaged in that kind of work and can utilize his own product as a small contractor and take his profits in that way, when the situation is somewhat different. The name, concrete building block, is a misnomer in connection with the industry as conducted at present, except in isolated cases, as the hollow block in general is merely a mortar block and in no sense concrete. Cement and sand do not make a concrete block, but

merely a mortar block, which will not bear comparison as to strength or beauty when contrasted with a concrete block containing the proper aggregates and which has been made by the same workman on the same machine. An economy of material, whether it be in cement or aggregates, is certainly a false economy and a menace to the manufacturer, as the result of such a combination is a block having but little strength ,no beauty and with a capacity for absorbing moisture only equalled by a bath sponge. Intelligent treatment of the material, both before entering the machine and after leaving it, are absolutely essential to commercial success.

LOCATION OF PLANT.

This is the first proposition to consider carefully, and the proximity to raw material, both sand and crushed stone or granite, should be well looked into, as well as facilities for shipping and receiving necessary materials. Good roads from the plant at all seasons are necessary, thus assuring an economical delivery of blocks to customers. The plant should be located on level ground, to allow the laying of tracks throughout the yard, and ample yard room is necessary for carrying a large stock of blocks. These matters having been arranged, the subject of a building should be taken up. The building should, if possible, be constructed of your own material, not only from the standpoint of economy, but to afford a specimen of your work, and care should be taken to permit only the best material and workmanship to enter into its construction. It should have ample floor space, governed somewhat by the number of block machines to be operated, and a good concrete floor should be laid in a portion, if not throughout the building, especially if the wet as well as the semi-dry process is to be used. At least, all of your machinery should stand on concrete floors. If the plant is to be devoted exclusively to the manufacture of blocks by the semi-dry process, or machine-made blocks, a practical equipment should be as follows:

First. A sufficient number of machines to give an average minimum daily capacity of not less than 400 standard sized blocks, as the investment called for would necessitate an earning not possible with a smaller daily output. There should be a mixer suitable to handle the dry and semi-dry material, having a capacity at least 50 per cent in excess of initial requirements, thus allowing the installation of additional block machines without change in

capacity of mixer. A crusher and rolls, together with a set of revolving screens, should also be installed to properly screen and crush the aggregates necessary to acceptable concrete work, and in connection with which there should be a system of storage bins, allowing the proper separation and storing of material, including cement, which would be bought in quantities. There should be a suitable arrangement of tracks throughout the plant and a sufficient number of cars to hold at least a two days' run of blocks. There should be an engine and boiler of sufficient horse-power to easily handle all machinery, including pneumatic tampers, as well as to furnish steam heat to the plant during cold weather, as any plant that is compelled to shut down during cold weather is not, as a rule, much of a money maker. There should be some system of economically applying water to the blocks, while curing, and the many devices of lifting hooks are not amiss. If the company make any pretension of furnishing stone of special sizes other than can be turned out on the block machines, it is quite necessary to have a competent patternmaker available. The active supervision of the plant should by all means be in the hands of some one who has a thorough knowledge of cement and concrete and who is capable of testing the cement used, as there is often a vast difference between the cement furnished on large contracts, such as government and other public works, and that furnished to the concrete block maker, even when a higher price is charged him.

I am not a believer in the water-proofing of blocks. On the contrary, it seems that the proper way to water-proof the concrete block is to do away with the necessity for such treatment by turning out a high-class non-porous block. This can be done by an intelligent grading of aggregates, so as to produce a material containing a minimum amount of voids, say 25 per cent, and then adding a sufficient amount of cement to completely coat each atom of aggregate, and to fill the voids. Blocks made in this way and properly cured and seasoned need no additional treatment. It is certainly inconsistent on the part of the block manufacturer to quote The Pantheon, Eddystone Lighthouse and other ancient specimens of concrete as showing the great durability of his product, and then to produce blocks that are so porous as to render it necessary to fill up the voids with such perishable material as paraffin and castile soap in order to keep moisture from the inner side of the wall. However, the water-proofing division will, no

doubt, be able to explain the necessity of their products to your satisfaction.

To sum up the situation, the time has come when the manufacture of concrete stone for building purposes has developed into a business requiring capital, brains and energy, and offers big returns to those possessing the requisite qualifications, but it has passed the plaything stage. Those of you who have engaged in the business for any length of time are no doubt aware of this fact, and even the trades journals are beginning to sound notes of warning, despite the large lines of advertising they get from this class of work. It is a good business to get into if you get in right, but otherwise, it is well to turn your talent to other lines. Immediate improvement in quality of work turned out is a vital necessity. The field for the semi-dry mortar block as at present manufactured is limited, on account of the quality and appearance of the material, to a certain field, which is neither large or lucrative. However, concerted action on the part of those now engaged in the work will quickly bring about an entirely different situation.

President Humphrey: I would ask Mr. Angell of the committee that has presented a report this morning if he will not make a few remarks on this subject.

Mr. Angell: About all I can say is, that the cement block business appeals to me as a business proposition; that I hardly ever saw anybody succeed in a business unless they go at it in a business way; and I think after hearing the papers we have heard this morning, on cement blocks, water proofing, etc., that there is no doubt as to the success of the cement block business. Of course, everybody cannot afford to be in a first-class plant, as suggested by Mr. Benson. There are other people who want to go into the business in a cheaper way. My advice to anybody who is going into the business is first to look around and see what you can find that will meet the requirements of the people. We must suit the builders and contractors and every class of people who anticipate building.

President Humphrey: I am going to ask Mr. Sherer to tell you what he knows about air tamping, conveying of concrete blocks, and other matters.

Mr. Sherer: In regard to the conveying of blocks I have not much to say. My experience is rather limited. The factory of which I have been in charge for years is built up around the nucleus of a small plant that was started eight or ten years ago. We find the style of conveying that has been cheapest and best all around is the decked car. We find that transfer tracks, with portable tracks out in the yard to various places where we wish to pile our blocks, has been the cheapest and best method. At one time we erected a trolley, on which we conveyed six or eight large blocks at once, but we found that that was not so convenient to place the product out in the yard and in various places. If I were to build a new block plant in a location where I had plenty of room, I would lay it out with a view of using the cars as being about the only cheap method of transporting the blocks from the factory to the yard and piling them up.

Relative to the air tamping, I will say that about a year ago we equipped our plant with pneumatic tamps. We coupled a

compressor to our shaft that operates our three mixers. Our equipment, which cost between $600 and $700, consisted, I believe, of a 300 horse-power boiler, air tank or reservoir, and the 10x12 air compressor, driven from our line shaft by belt, with piping, etc., that we used to convey air to the different parts of our factory, and it has been the best investment of modern times that we have placed in our factory. The results obtained have been very satisfactory in many ways, from the fact that we obtain a much denser product, having our blocks more solid, easier to handle from the fact that they stand up better, with a semidry mix. To an ordinary block it will add perhaps from 4½ to perhaps as high as 5½ pounds per foot of block to the weight of your block, owing to the putting of more material into your block. However, I think that it is well put in, owing to the character of the block you get from this method. We experienced, at first, some little difficulty with our tamping tools. We were not aware, at first, that there might occasionally be some condensation in the pipes, and our tools refused to work at times. The mechanism of these tampers is very delicate. They must be kept well oiled in order to get good service. Having a very intelligent foreman, he examined and took the tools apart, found nothing that seemed to interfere with them until it occurred to him that he should uncouple them near the tool; and by putting the hand up in front of the air we found there was considerable water thrown out. We learned afterwards that there was a drip cock to our tank that we did not at first know about; which, if we had known enough to have turned at times and allowed the air to expel this water, we would have had no bother. If you ever equip a tool of that character, look out for your condensation, because it interferes with the working of your tool very materially. As regards the tools and repairs, I am often asked, do you have much difficulty in keeping them in repair. We are equipped with four sets of tools. We keep one idle most of the time, so that if anything does happen we always have one to put in its place. I will add that we have found that the advantage in tamping with air has been more in the larger articles, such as sills, lintels, and in the larger blocks, than in the smaller ones. Of course, the larger the body of concrete that you have to tamp, the greater the difference in the speed in getting out the number of sills or lintels that you have to make. It increases

very materially. The first tab I kept on my product was when we were using a large 30-inch block machine. We found that in running four days consecutively and in keeping an exact account, with one less man on three machines, we increased our output 55 per cent by using the tamper, which fully repaid us for any expense we had had, and we shall continue to use it until we find something better.

Mr. Seafert: What is the pressure?

Mr. Sherer: We are carrying 80 pounds pressure, with a 7-inch stroke. We intend to equip our sewer pipe department with a longer stroke and stronger and heavier tool. I am asked sometimes if the vibration of that tool in the men's hands is not detrimental. We have never had any of our men refuse to take the position. While we have them change at times after working two or three hours, none of them refuse to take the position and handle the tool. They don't seem to have any ill effects from it whatever. We used what is called the spade-handled tool with a round barrel, in which the valve is located at the top or on the spade handle, and the man handles the tube in the other hand, with which he can guide it very nicely. The hose is flexible, and it in no way interferes. We find, however, that it is to our advantage to have our man stand well above his work, as he can direct the tool to much better advantage.

Mr. Seafert: How many pounds does each stroke deliver upon the face of the block, and how rapid?

Mr. Sherer: Two hundred and fifty strokes per minute, I believe, is what is calculated, but the weight of that stroke I am unable to state. I do not remember now.

Mr. Seafert: I understand there is one in use now in Chicago that delivers a blow of 80 to 120 pounds.

Mr. Sherer: I believe that is about the estimate. This much I can say, that the blows are very even, and that where a fracture is made in our blocks we find it very even and the concrete well packed and compressed in all parts of the block. I was requested by one of the block men to tell a little something that occurred in our city recently relative to our city ordinance. The building inspector, who is very liberal in his ideas, has framed or codified this ordinance, and is waiting for us in the block business to put in that portion referring to blocks. We are now making some tests in that line. Our mayor had agreed to have the

city furnish us a testing plant, and we are now making some tests to obtain data on which to base a report. We will submit to any physical tests that may be required of either brick or stone, but we should not be penalized for air space. Our walls should be compared with walls of other material on the basis of the gross section.

The following recommendations were made by the block makers to the building department of Milwaukee, Wis.:

It was recommended that Milwaukee should have a testing station, wherein a testing machine should be installed that would test the crushing strength of blocks. The amount of crushing strength each block should stand should be determined by comparison with that which other building materials are supposed to have. Crushing strength, furthermore, should be determined upon the total area of the surface of the block.

It is further recommended that it should lie within the jurisdiction of the building inspector to determine the strength of a wall while it is under construction and at such stages as should be deemed advisable, it being incumbent upon the contractors erecting such building to lend whatever aid is necessary to the inspector of buildings in testing a wall.

It is recommended that blocks should be manufactured thirty days before they are permitted to enter into the construction of a building. However, if a contractor has sufficient confidence in the short time cure for his blocks, according to the system he employs, to place such blocks in a building before the thirty days' time limit, he first must place a block with the building inspector, who shall not test same until after the expiration of thirty days, and if such is found wanting in its crushing stength, he shall be required to tear down his wall. It shall further rest within the jurisdiction of the building inspector to go to a building when under course of erection and pick out such blocks as he desires for his test, and if such blocks do not comply with the regulations for determining the crushing strength a block should have, the contractor must tear down his building.

It is further recommended that it rest within the province of the building inspector to test the cement used in the manufacture of blocks, as well as examine the aggregate used.

It is recommended that Portland cement be used exclusively

in the manufacture of concrete blocks. It is deemed advisable, furthermore, that the manufacturers of concrete blocks be licensed and that they shall furthermore put up a reasonable and just bond with the city as a guarantee that they will live up to the requirements of the law in these matters and the instructions of the building inspector.

It is respectfully suggested further that this code be made reasonably stringent, to guarantee a high standard of blocks, and that blocks made under reasonable regulations be equally entitled to the recognition of the code in the construction of all classes of buildings with any other building material. It is believed that the portion of the building code specifying materials that can be used for outer walls, for division or fire walls, etc., should include concrete blocks, and not have them inserted in the code, as they are at the present time, as a kind of auxiliary material.

Mr. Harper: In one of the recommendations I notice that in compressive resistance of the block you stated that the entire area should be taken. I wish to ask Mr. Sherer whether he meant the gross area, inclusive of the air space, or the net area, exclusive of the air space?

Mr. Sherer: The gross area, including the air space.

Mr. Harper: I would like to know from Mr. Sherer why he takes the entire gross area instead of the net area, exclusive of the air space?

Mr. Sherer: If we were compelled to make our cement blocks solid, as the brick wall is, we would simply go out of business. If we do not have the advantage of the air space the block business would not be a success commercially. Take a cubic foot of brick, as compared to a cubic foot of blocks. We claim that we give them all the strength that they require, with a factor of 6, 8 or 10 perhaps. For instance, if our building inspector wants 1500 pounds per square inch on his brick in any thickness of wall, we give it to him.

Mr. Harper: Unless you have the area of air space, so that we could make the deductions, I don't believe that the test is comparative, and that you can figure it with a brick wall. In the New York code there is required a compressive strength of all new materials of 3000 pounds per square inch. Prof. Woolson has conducted a very completed series of tests upon the com-

pressive strength of the different materials. I asked him if he did not think that 3000 pounds compressive strength of new building material in New York was excessive. He said they found that the brick that they used in New York ran over 3500 pounds to the square inch, and that they had determined that 3000 pounds was a reasonable amount, and the sand-lime brick men assembled at that convention did not find fault with Mr. Woolson. They said: "If we wish to go into the New York market, we must study our product and see if we cannot make a superior article, so that it will meet the code." Mr. Woolson failed to add what he did to me afterwards—that in building we do not require 3000 pounds per square inch. A manufacturer of cement brick claimed tests up to 10,000 pounds per square inch. Concrete will stand in compression from a few pounds, according to the mixture and according to how it is cured, up to say 5000 pounds or a little better. I have yet to find any concrete in my experience that would run up to 10,000 pounds.

Mr. Sherer: All we asked was a starting point. We took brick as that starting point. We claim more for the hollow space in the block than merely a necessity for making it a commercial success. It forms an excellent insulation against dampness. The block industry has come to stay, and all we ask in this new specification is to make it as simple as possible to meet the demands of the public and be satisfactory to the block industry without entailing, as the Philadelphia code does, a series of experiments through which I am sure no block manufacturer in Milwaukee is satisfied to go in order to stay in the business. What we want is a straight chance to put our material in competition with other materials and do it as easily as possible with the best results, financially and otherwise.

Mr. W. J. Scott: In answer to Mr. Harper's question, the suggestion regarding the manner of testing the net area of a block, as compared with the gross area of a wall or cross section, I would say that no matter what we may recommend, a wall constructed of brick 8, 12 or 16 inches in thickness is required to sustain the dead weight of the wall, the weight of the floors and the live weight of the building. A wall of concrete blocks with 25, 30 or 50 per cent air space must sustain the weight of wall and floors and the weight of the building on those floors. We must sustain on a shell as much as a solid brick wall sustains, and

because of that we must have in our net measurements a gross strength equal to the gross strength of the solid brick wall.

Mr. James M. Carrere: The load on the wall, according to the code of New York, does not apply to a curtain wall. I do not see why it should not be just as fair to figure the load of a hollow block the same as you would a hollow iron or steel column. The load that is to be put on the block would determine what the block has to carry, just the same as it would on a column or any other wall; and the fact that the brick is not hollow should hardly interest block makers or even the experts of the city. As long as the city engineer is satisfied to specify a certain load per square inch for a wall, all that he is interested in is to know that the material he is using will carry that load, and I quite agree with Mr. Sherer in adopting that policy. I am not saying anything about 1500 pounds, though.

Mr. Daniels: I have found two persons only who can tell me that they have made tests. I do not believe they would be satisfactory to the chief engineer of the building department of New York City. The authorities who are codifying the laws under which we must work want reliable information and they come to ask us for it, and we are unable to tell them how strong the material is which we use. If I, in the East, use a certain sand and a certain aggregate, my test is perhaps of practically no value to you, because the material which you use, your sand and your aggregate, will be entirely different. We, therefore, will have to come to a basis of strength, it seems to me, so that we will know that a cubic inch or square inch of our material will show a certain compressive strength. I would suggest that you take the material from your mixing machine and put it into the specified form, tamp it by hand or by pneumatic tamper, as you may be accustomed to do, and put it into your yard, or curing shed, just exactly as you would do in a block form; and then at a certain interval have these briquettes tested by some designated authority. I have in mind a certain sand mixed, 1 to 3, according to voids, which gave 1000 pounds compression strength. Taking coarser dust, reducing the quantity of sand, using the same cement, the entire mixture being made at the same time as the other, and tested at the same time, 1 part of cement, 2 of sand and 4 parts crusher dust resulted in a block nearly three and a half times as strong as the first block. What is the

result? Four blocks in place of three in the same bag of cement. This is important to you in a financial way. You can make your business better and can handle them to better advantage by conforming to a stated specification; but, on the other hand, if the block only shows 500 pounds of compressive strength, you are ruining your own business and are ruining the business of the rest of us.

OBSERVATIONS ON THE TESTING AND USE OF PORTLAND AND NATURAL CEMENTS.

E. S. Larned.

The present remarkable development in the use of cement is the direct outcome of the careful and persistent observations and experiments of our engineers, mechanical, chemical and civil. There is not a structure of modern times built of natural stone or forms of burned clay that has not been duplicated in cement, and the latter is now meeting structural requirements hitherto impossible except by the use of iron, steel and timber and its advantages over the latter materials in the matter of cost, durability and freedom from injury by fire and water is only just coming to be known. Time has shown when cement is carefully selected and treated intelligently in the practical work of construction, enduring monuments are founded to the honor and credit not alone of the designer and builder, but, in justice, be it said, to the pioneers and courageous supporters of this important industry in our country, who have persevered in face of many discouraging and adverse conditions until the American product is recognized as standard the world over.

While the rapid growth of the Portland cement industry since 1895, and the extended use of the material in all forms of construction, may well be taken as a tribute to its improvement and reliability, the better understanding and appreciation of not only the users but of engineers and architects as well, must also be considered of the utmost importance. Hydraulic cements have been made and used for more than a century, and yet it has remained for investigators of comparatively recent years to throw much light upon the subject and the light must be disseminated widely before the full benefit will be derived.

The adoption of a standard specification for Portland and natural cements during 1904, by the Joint Committee of the American Society of Civil Engineers and the American Society for Testing Materials has proved a happy issue out of the maze of conflicting requirements the manufacturer has met with

throughout the country in years past. It was perfectly natural, under such conditions, that doubt and suspicion, of a product as little known, should prevail among the uninformed, and the American manufacturer of Portland cement, the agent for foreign cement as well, was often regarded as a necromancer when he was enabled, through his superior knowledge and experiences, to demonstrate that a cement in question was all right for use. Before the adoption of the standard specification (and even today to some extent), much conflict of opinion was found upon some of the most vital principles governing the acceptance of cement. Each tester or engineer performing this duty was a law unto himself, and exercised the full prerogative of his official position in fixing requirements and interpreting results, oftentimes prescribing tests that were misleading and fallacious as an indication of quality and only served to vex and hamper the manufacturer and in such cases an effectual barrier was set up between the very interests that have since combined and co-operated to the great benefit of all concerned.

In the absence of better information, it may be natural for the user of cement to entertain with suspicion the statements of the manufacturer affecting the quality of a cement in question, but it seems obvious that with standard specifications and uniform methods of testing combined with full and up-to-date information upon the results of the several determinations made, there would follow greater uniformity in the material, less opportunity for dispute and a greater degree of confidence and mutual respect between men who are seeking the same attainments—excellence of material, design and workmanship, in all projects that mark the prosperity and progress of our country.

With an experience covering nearly eighteen years upon important hydraulic construction, I have found opportunity to observe many variable conditions affecting the requirements and use of cement, and I know of no material entering into construction of which so much is expected, that is subjected to the same or equal abuses, and when a failure is recorded, happily very few, how common it is to see the cause ascribed to the cement.

An idea will obtain in the classroom, office or laboratory that, if carried out or closely approximated in the field, would

give excellent results, but how often this is forgotten or overlooked, and crude, yes cruel, methods of work be suffered and this can under some conditions, be said even of cement testing. Young men are sometimes selected for this work without previous experience or any knowledge whatever of the subject, and though one may have a high degree of intelligence, and be industrious and conscientious in his work, under good or indifferent supervision, yet the best that can be said of such a selection is that to pass a poor one, although the latter chance is not remote; little consideration is shown the manufacturer or the reputation of his product.

Once asked to explain the difference in results obtained by two testers working together, using the same amount of water in mixing and following the same methods of moulding, etc., I offered the somewhat parallel case of two cooks making bread from the same barrel of flour, same yeast, and same formula throughout, and yet the quality and appearance of the loaves would be quite unlike.

The personal equation, perhaps, may not be removed in testing cement, but other conditions that vitally affect the results can be brought to a more uniform basis, and these in ordinary may briefly be summed up as the quantity of water used to produce a paste or mortar of given consistency, time and manner of manipulation, method of molding, temperature of water, and air, time and conditions of exposure in air and water, and rate of applying the load.

When tests are made under the instructions of the standard specifications by an experienced and skilled operator, they form a record valuable not alone to work in which the material is being used but to all users of cement who may have access to the results. Uniform tests, under a standard specification serve to show:

First.— Whether the material meets the standard or fixed requirements.

Second.—Uniformity of the product tested.

Third.—A comparison with other brands of the same material, which is invaluable at times when making a selection and computing the real relative net vaues.

Without a uniform specification and uniform tests thereunder, it is obvious that results could give no indication of uni-

formity of product, and a comparison with other brands or of the same brand tested at other points would be meaningless to a great extent. Training and experience are regarded as essential in any technical, mechanical or professional work to produce results that are scientific, accurate and dependable. The operator must know the full significance of his determinations or he will at times omit some details or overlook a precautionary measure that may have a marked effect upon his results. Only trained, experienced men should be intrusted with the testing of cement on important public or private work where results are carefully tabulated and published in reports or otherwise circulated, and it is of great benefit and interest to all users of cement that we may have such results to refer to. The small or casual user of cement hardly finds it expedient or necessary to attempt a chemical analysis or test for specific gravity. In fact, when he is using a well known and established brand he need feel little concern about this, and the tests for soundness, sand-carrying capacity (which he determines by tensile tests of sand mortars), times of setting and firmness, all together have a bearing on the chemical proportions and specific gravity that means much to the experienced observer.

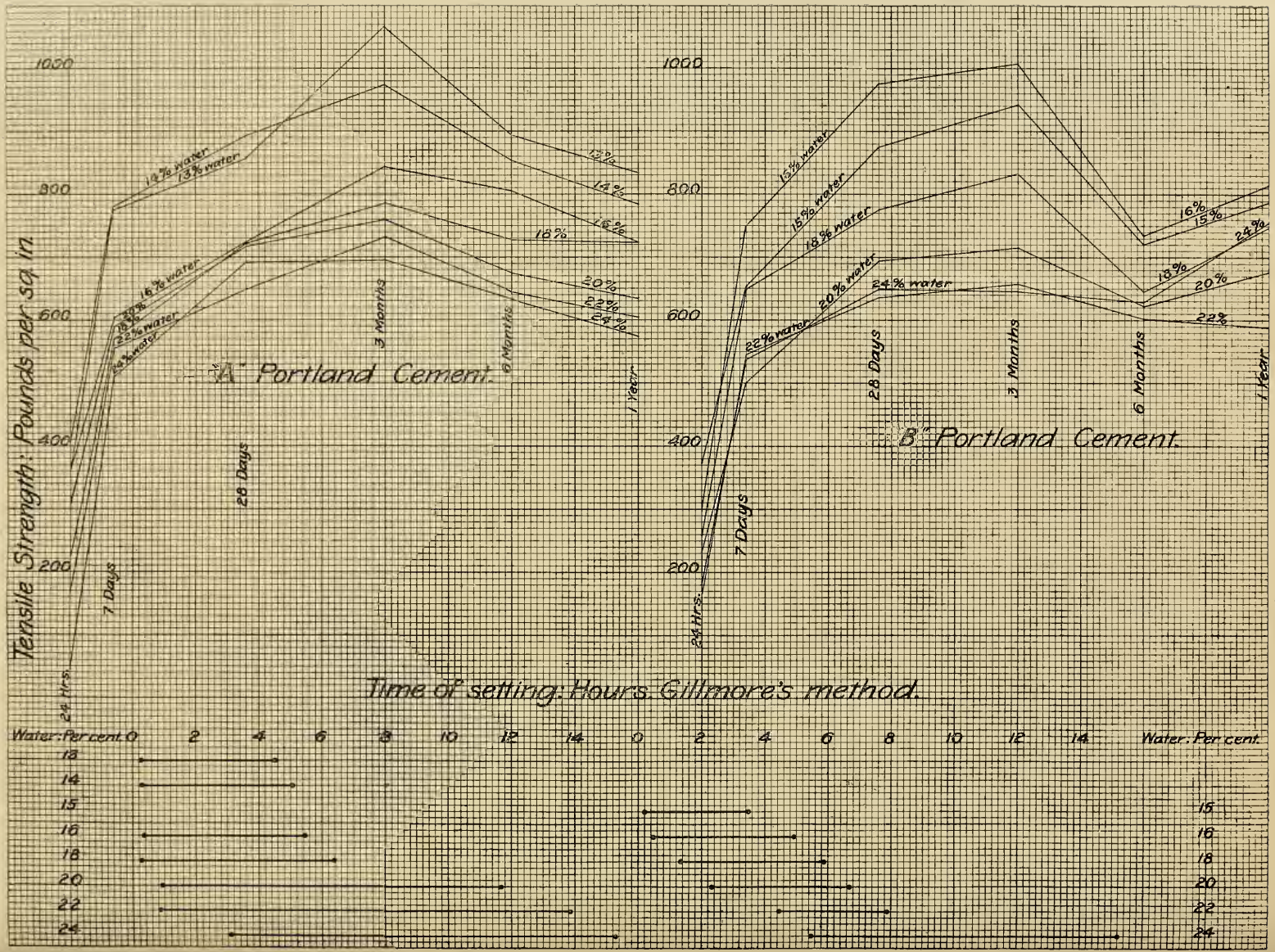
Tensile tests of neat cement are useless in determining the real relative strength of one or several brands of cement and the proportion of 1 cement to 2 sand, by weight, should alone be considered in making comparisons. We use the cement with sand, not neat, consequently we want to know what to expect in our work. Many cements both Portland and natural give very satisfactory results in the neat test, but show marked inferiority compared with the best brands of both grades when tested for their sand carrying capacity. Unless the standard Ottawa sand or crushed quartz be used throughout the test, we must recognize the fact that variable results will follow that are not due to the cement.

The effect of water in retarding the induration of cement and reducing the tensile strength, particularly at short periods, has long been known, and more or less information has been published as the result of experiments made.

The writer was led to make a series of tests on these lines during 1901, in somewhat more detail than anything he had

seen published, and it is the result of this experiment that we will now consider. It may be stated that one man made the briquettes for the entire series, six for each period, at each interval in the amount of water used; the water in mixing was at a uniform temperature of 63 deg. F. and the temperature of the air averaged slightly under 70 deg. F. and fluctuated between 50 deg and 75 deg. F. Two briquettes of A. S. C. E. standard form were gauged at a time, and beginning with the dry mixtures the molds were filled in three layers, each rammed successively until flushed, by hand, using a hard-wood pestle, and finally struck off and smoothed with a trowel. The ramming process continued until the mixture became too soft, when the molds were filled by pressing in with the thumb and trowelling. So far as possible, the briquettes were allowed to set in air, under a damp cloth, about two hours after taking the heavy wire before immersion; this could not be followed uniformly, and some of the softer mixtures were allowed to set in air overnight, and in a few instances the operator was obliged to wait late in the night to complete his observations. In determining the rate of setting the Gilmore needles were used and care was observed to use the same samples of cement throughout the series, and this was taken from the storehouse of contractors engaged in the construction of large public work.

Chemical analysis of the cement here considered were not made for this test, but the characteristics of the brands named are perhaps well known to many, and will be only briefly referred to. The A. and B. brands of Portland cement both came from the Lehigh district of Pennsylvania, and, in their chemical composition, are in quite close agreement. The natural C brand is also made from the crystalline cement rock of the Lehigh district, is light in color, and its composition is quite unlike the D. brand, which is dark in color, being made from the magnesian limestone of the Rosendale district, New York. C brand more closely approaches the Portland standard in composition and differs from the D. brand noticeably in its lime and magnesian content, having about 50 per cent. lime and 2 per cent. magnesia, while the D. brand has about 36 per cent. lime and from 16 to 18 per cent. magnesia, which is characteristic of about all the New York Rosendale cements. The low magnesia content, together with the very fine grinding of C., cause it to be more active and


Tensile Strength: Pounds per sq in
1000
800
600
400
200
"A" Portland Cement.
"B" Portland Cement.
12% water
13% water
14% water
15% water
16% water
18% water
20% water
22% water
24% water
24 Hrs.
7 Days
28 Days
3 Months
6 Months
1 Year
Time of setting: Hours. Gillmore's method.
Water: Per cent.
0 2 4 6 8 10 12 14
12
13
14
15
16
18
20
22
24

quicker setting than D., and this is well shown in the table and diagram, particularly in the wetter mixtures.

As might be expected, this difference in the cements, tested neat, would be in greater contrast when combined with sand in concrete mixtures and it was, in fact, the dissimilar results in practical work of construction that led to this experiment, and I regret that the experiment did not also include mortar mixtures, in the proportion of two sand to one cement, in the Natural cement, and three sand to one cement for the Portland, wherein conditions would obtain more closely approximating the operations of every-day practice.

From personal acquaintance with a recent large work of concrete construction the writer is forced to the conclusion that when any reliance must be placed upon the cohesive strength of Rosendale cement, within six months, and perhaps longer, depending upon the exposure and local conditions, great care must be exercised in proportioning the amount of water used, or, in the present day of wet concretes, in selecting a cement that successfully withstands the deteriorating influence of an excessive amount of water.

In the diagram of tensile results the dryer mixtures of the D. cement show superiority up to the 28-day period, at which time it is quite marked and uniform; the gain in strength between the 24-hour and 7-day periods appears slow, and grows as the amount of water is increased; the improvement between the 7-day and 28-day periods is better, but the rate of gain appears generally in favor of the dryer mixtures; the gain in all mixtures between this and the three months' period appears quite uniform, and develops a rapid gain for the wetter mixtures. After the latter period inconsistencies develop, and between six months and one year only the 37 per cent. and 39 per cent. series show any appreciable gain, and the wettest mixture appears superior at the end of the year, the others generally showing a falling off in strength, for which I can offer no explanation.

In the C. cement series the dry mixtures generally appear superior at the 24-hour and 7-day periods, the rate of gain is quicker, and quite uniform; as in the Portland cements, the gain in strength of the wetter mixtures is more rapid between 7 days and 28 days, the wettest mixture having passed four of

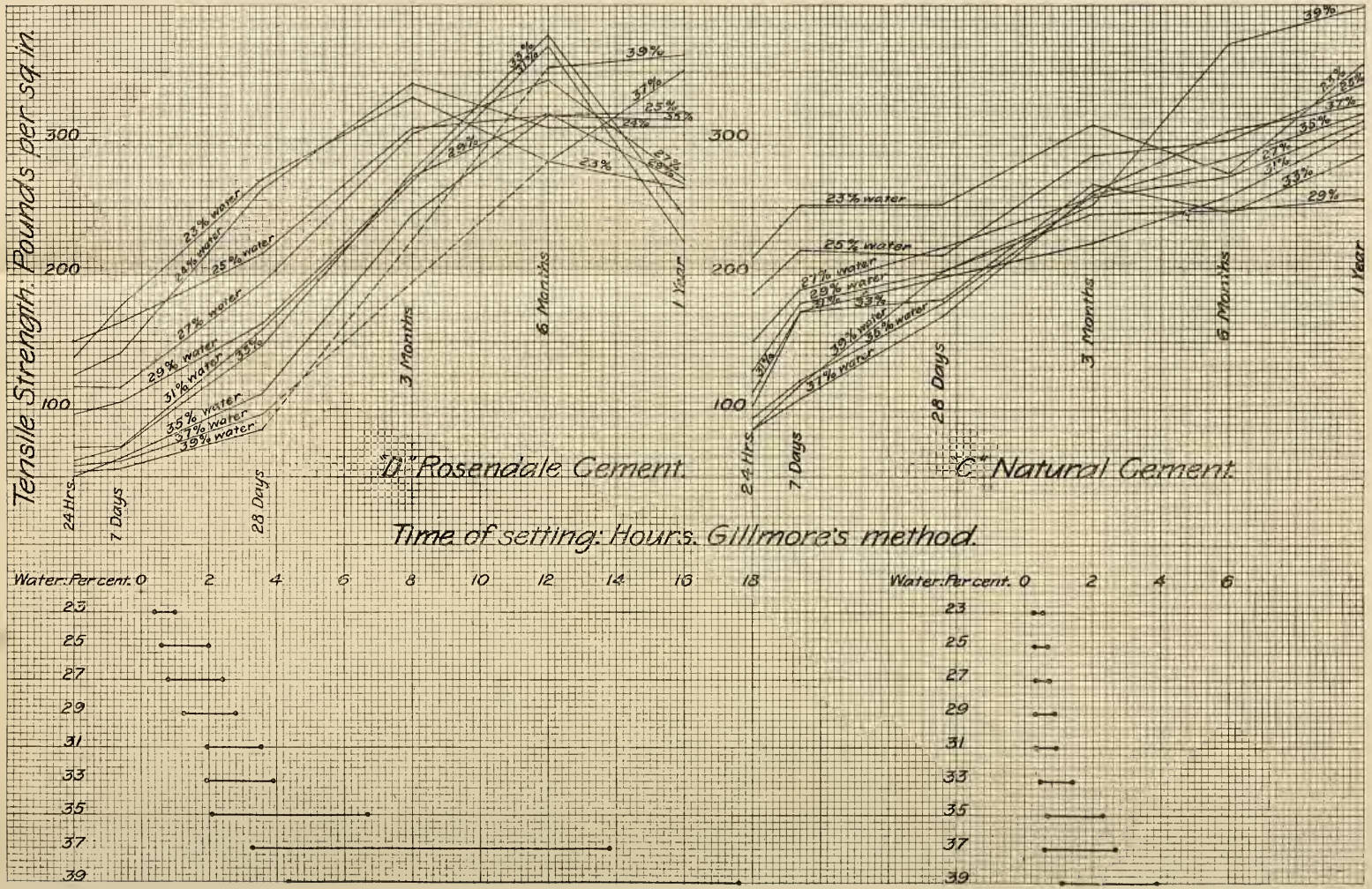
the series next below, and all of the series being closer together than at the two earliest periods; at three months only the 23 per cent. and 25 per cent. series held their superiority, the wetter mixtures rapidly overtaking all others and being in close agreement, with the exception of the 31 per cent. series, which made a slower gain; after this period peculiarities develop for which no explanation can be offered, but the uniform rate of improvement is noticeable in all instances, and the results at one year are better in each case than at any preceding period, the 23 per cent, and 33 per cent. series showing a falling off between three months and six months with a good recovery at one year.

In the Portland cement series the rapid and uniform improvement between 24 hours and 7 days is noticeable, but the dryer mixtures generally hold their superiority. This is noticeably uniform in the A. cement at all periods; the maximum strength was attained at three months after which, and up to one year, there appears a steady falling off in strength but from three months on the dryer mixtures are uniformly better.

The B. cement also attained its maximum strength at three months, at which period the dryer mixtures also appear uniformly superior with the exception of the 15 per cent. series; and judging from the results of this series throughout the test, it would appear that there was not quite enough water used to perfect the crystallization of the cement. The B. cement also shows a falling off between three months and six months, but a good recovery after this latter period in all but one series, 22 per cent, and the wettest mixtures 24 per cent., passed the three series next below at one year, two of them in fact in six months. and between six months and one year it showed a more rapid gain than any of the other series.

The personal equation is apparent in these tests, as in any test of the tensile strength of cements, but every effort was made to secure consistent and uniform results, and I will repeat that one man made the test throughout the entire series for the four cements named.

Cement or concrete construction, with or without steel reinforcement, is coming rapidly into favor, supplanting steel, stone, brick and lumber in all forms of construction, and it is but natural that mistakes and failures sometimes attend the efforts of the inexperienced and certain retribution is in store


Tensile Strength: Pounds per sq in.
300
200
100
23% water
25% water
27% water
29% water
31% water
33% water
35% water
37% water
39% water
24 Hrs.
7 Days
28 Days
3 Months
6 Months
1 Year
"D" Rosendale Cement.
"C" Natural Cement.
Time of setting: Hours. Gillmore's method.
Water: Percent. 0 2 4 6 8 10 12 14 16 18
23
25
27
29
31
33
35
37
39

for the dishonest workers, but it is a remarkable tribute to this comparatively new material that so few failures have been recorded during the phenomenal growth of the industry. In fact, the failures in brick, timber, and steel frame structures are more numerous than in concrete construction, and yet all are chargeable to carelessness or dishonesty; let us hope that each will serve as a beacon light to prevent a like calamity in the future.

Low first cost is not necessarily ultimate economy; if concrete did not perform its duty well and stand the test of "time," other materials would surely supersede it. It is of the greatest commercial importance to all in the industry, that quality should be a first consideration, you well know how the slightest imperfection in concrete work is pointed out by hostile interests as a sign of inferiority or failure, and a small crack which would be overlooked in brick work is viewed by the uninformed as a forerunner of sure and sudden collapse. Use only high grade cement, select your sand with care and beware of sand containing loam or clay. Clean siliceous sand ranging from fine to coarse gives the best results; test it in combination with your cement before using. The ballast of coarse aggregate should also be clean, and of varying size in order to reduce the voids to a minimum. Gravel and igneous rocks furnish the best stone for concrete, much better than limestone for fireproof construction. For crushed stone, use a 1-4-inch mesh dust jacket on the sizing screen, you will then have a more uniform product. The amount of dust varies with the size, shape and character of the stone crushed, also depending upon the rate of feed into the crusher, the speed of the crusher and the degree of moisture in the stone. Stone dust, if clean, is better than most any sand, but should be accurately gauged as sand, and more care is required to thoroughly incorporate it with cement because of the large percentage of fine material contained.

If crushed stone is stored or binned, as in most work requiring reserve stock, a more uniform mixture can be drawn from the bins when using, if the dust be excluded, the latter serves to pack or cement the stone together and alternating loads of coarse and fine will surely result.

In securing quality, thoroughness and care of mixing and

placing concrete are of the utmost importance; carelessness in placing will undo the work of mixing.

Proportions of cement, sand and stone will vary, depending upon the work to be done, but it is well to keep in mind:

First.—That the stone voids should be a little more than filled with sand, and the sand voids a little more than filled with cement, (if strength is desired).

Second.—That the voids in ordinary sand vary from 30 to 42 per cent., so that if leaner proportions than 1 cement to 3 sand be used, the cement will not fill the voids and the mortar will be porous.

Third.—Accurate gauging is essential to uniform results. A word as to consistency or amount of water used: Wet concrete is the order of the day, and while I believe in using too much rather than too little water, still, in my judgment, much concrete is made too wet, and if in this condition much tamping, spading or forking be done, the coarse aggregate will be driven to the bottom of each layer placed and a very unequal distribution of cement throughout the mass will follow. Except in the presence of very intricate reinforcement the mortar should be of a consistency to easily support the coarse aggregate and admit of light tamping. Excess water serves to undo the work of thorough mixing.

With the view of determining the variability of wet mixtures, the writer made the following test this past year:

Gang molds were placed vertically over each other, eight in all, to represent a layer eight inches deep, the joints between moulds were sealed with a thin layer of a mixture of white wax and tallow to prevent the escape of water. A high grade Pennsylvania Portland cement was used in the proportion of 1 cement to 3 parts of Standard Ottawa sand, by weight, gauged with 20 per cent. water. Fine anneal wire (32 gauge) was inserted between each mold and when the mixture had partially set these wires were used to cut the gang moulds apart, and the operation was satisfactory in producing perfectly formed briquettes. The briquettes were allowed to remain in the molds over night, under a damp cloth, and were then removed and immersed in water until broken.

The consistency of this mortar compares closely with much of the wet concrete now used, dryer than some I have seen used

in large work. When the molds were filled the mixture was churned and worked with a glass rod about 1-4 inch in diameter. The following results are the average of 3 briquettes, a total of 48 being in the series. No. 1 briquette is from the top layer and No. 8 from the bottom:

	Number.	Tensile Strength 28 days.	Pounds per sq. inch. 45 days.
Top	1.	336	386
	2.	288	392
	3.	225	354
	4.	255	318
	5.	222	292
	6.	219	289
	7.	288	241
Bottom	8.	303	265

The purpose of this experiment would have been accomplished in the test for one period alone, but it was deemed inexpedient to make the trial for any time short of one month. The inferiority of the briquettes in the bottom layers is clearly apparent, there being a maximum loss in strength of 117 pounds at 28 days and 151 pounds at 45 days.

It would appear entirely reasonable to assume that a greater variation would be found in a seven day test than in either of the above two noted. Concrete to be of the utmost value should be a true monolith of uniform strength throughout, this is of vital importance in beam, girder and slab construction and is not difficult of attainment.

This would seem to suggest that the idea is worthy of serious consideration, and further experiment, in the line of compression tests also, may bring forth interesting facts.

Another tabulation is also given showing the tensile strength of Portland cement mortar mixed in the proportion of one cement to two sand and gauged with different percentages of water, ranging from 8 per cent. to 20 per cent.

Sand known locally as "Plum Island" sand, was used. This is a dredged sand, very clean, selling at $1.60 per ton delivered. High grade Pennsylvania cement was used. The results given are the average of three briquettes. Percentage of wa-

ter used was determined on the combined weight of cement and sand. Briquettes were immersed in water until broken after remaining in a moist air closet 24 hours.

The injurious effect of using too little water is plainly evident in the 8 per cent series and requires no further emphasis. Up to six months the superiority of the dryer mixtures. excluding the 8 per cent. series, is quite uniform and it would appear that from 12 to 15 per cent water would give the best results in a mortar of this composition namely 1 cement to 2 sand, 14 per cent. water will yield a very plastic mortar if properly tempered.

PORTLAND CEMENT MORTAR 1 CEMENT TO 2 SAND.

Water—Per cent.	Tensile Strength, Pounds Per Square Inch.					
Time of Test.	8%	12%	14%	16%	18%	20%
7 days	261	433	392	368	338	301
28 days	344	470	447	436	422	407
3 months	344	490	494	491	457	454
6 months	392	543	536	497	472	430
12 months	300	463	478	434	446	474

It is gratifying to note the growing appreciation of the important part sand plays in all cement work for in very many instances poor results are directly chargeable to the sand used. No cement will improve properly if mixed with very fine sand, and results will vary depending upon the characteristics of the fine material. It must also be kept in mind that an intimate mixture of cement and fine sand is very difficult to attain, and a thorough distribution of cement throughout the sand voids is absolutely essential to good results.

Sand that looks good is not always above suspicion and the following instance will serve to show the importance of testing the sand before use. An important hydraulic work was begun last spring in New Brunswick and the contractors and engineers had congratulated themselves upon having what appeared to be an ideal deposit of sand and gravel for concrete work. The cement was thoroughly tested with standard sand and found O. K. When everything was ready an active start was made and considerable concrete was placed before any doubt arose; it would not set up, however, in a week's time (or longer it proved), and the cement was immediately tested again with fa-

vorable results and then some of the sand was examined. On the washing test it was noticed that a slight opalescence was imparted to the water, remaining in suspension several days, but leaving practically no deposit on sedimentation. The cement was then tested with this sand before and after washing, and the trouble at once located. The sand and gravel were both washed thereafter and good results followed.

A tabulation is added showing the tensile strength of cement mortars in the proportion of one part of sand to one cement, by weight, for Rosendale or Natural cements, and two parts sand to one cement for the Portland. A siliceous sand was selected for this test, carefully screened to the sizes noted and combined in the proportions given in the table. The test was made to determine the relative value of sand grains of different diameters, in combination with cement, and also to study the effect upon the tensile results of adding fine material.

Few unwashed natural sands are free of dust, of a loamy or clayey nature, containing a high percentage of organic material, and in specification usually calling for sand clean and sharp and free from fine material, the importance of excluding this deleterious agent is recognized but it is not always possible to enforce this absolutely, and from mechanical analysis of a large number of samples, and casual inspection of sand in use at various points, I am satisfied that much sand is used that contains 5 per cent. dust, and a good deal that carries as much as 10 per cent., and even more in some instances.

The fine material passing the No. 100 mesh screen, used in this test, was obtained from a clean, white siliceous sand, and if, with increasing amounts of this material, a falling off in tensile results appears, it can in no sense be taken as a measure of what would follow by using sand containing a dust of loamy or clayey nature, but is in a way suggestive. The cements used in this test were of the same samples as in the other tests previously referred to.

The sand mortar test is the true basis upon which to judge the value of a cement, and I believe the proportion of sand to cement should be the same as employed in the actual work of construction. Unfortunately this was not carried out in the above test of the natural cements for the reason that results were desired, for purposes of comparison, with previous tests in the same

TENSILE STRENGTH OF CEMENT MORTAR WITH SAND GRAINS OF DIFFERENT DIAMETERS

Results given are the average of six briquettes.

Sand Gauge per cent. used.				Natural cement mortar 1:1.								Portland Mortar 2:1.			
				Water per cent.	C			Water per cent.	D			Water per cent.	B		
No. 30.	No. 20.	No. 100.	Fine.		7 days.	28 days.	6 mos.		7 days.	28 days.	6 mos.		7 days.	28 days.	6 mos.
															412
100	...	...	...	17	156	193	352	15	115	163	314	10½	286	288	473
...	100	...	...	17	151	194	349	15	118	146	286	10½	294	331	294
...	...	100	...	17	153	187	340	15	91	110	257	10½	201	226	223
...	...	...	100	17	100	123	307	15	71	76	186	10½	129	159	486
80	10	10	...	17	154	210	358	15	94	124	301	10½	361	380	428
70	15	12½	2½	17	142	190	332	15	86	107	254	10½	301	303	419
60	20	15	5	17	143	192	342	15	83	107	285	10½	307	311	538
50	25	17½	7½	17	140	208	345	15	80	89	291	10½	391	400	475
40	30	20	10	17	133	197	362	15	90	82	296	10½	350	355	475
30	25	30	15	17	123	191	329	15	78	77	266	10½	362	359	478
20	20	40	20	17	128	199	318	15	66	73	285	10½	317	374	480
10	15	50	25	17	122	201	324	15	68	72	221	10½	291	354	488
50	...	...	50	17	108	193	317	15	62	70	239	10½	247	287	351
50	50	...	...	17	154	222	323	15	82	107	316	10½	440	408	542
50	...	50	...	17	150	210	344	15	78	88	290	10½	309	336	438
25	25	25	25	17	125	183	302	15	74	68	250	10½	279	337	477
	Crushed	quartz.													
40	...	60	...		179	256	{ 3 mos. 355	14	93	100	{ 3 mos. 142	9½	257	331	{ 3 mos. 351

MEMORANDA—All proportions and percentages determined by weight.
Natural sand used, first passed through No. 8 screen and residue excluded.
No. 30 sand passed No. 20 screen and caught on No. 30 screen.
No. 20 sand passed No. 8 screen and passed on No. 20 screen.
No. 100 sand passed No. 30 screen and caught on No. 100 screen.
"Fine" is clean white sand sifted through the No. 100 screen.

TABLE SHOWING TENSILE STRENGTH OF CEMENTS MIXED NEAT WITH DIFFERENT PROPORTIONS OF WATER.

Cement brand.	Water per cent	Sieve test; residue on.			Wire: minutes.		Tensile Strength.					
		No. 50.	No. 100.	No. 180.	Light.	Heavy.	24 hours.	7 days.	28 days.	3 months.	6 months.	12 months.
B Portland.	13											
	14											
	15	0.15	5.4	21.2	12	207	371	655	875	941	720	787
	16	...	...	...	29	297	303	750	973	1008	735	816
	18	...	...	...	80	355	260	649	773	831	645	748
	20	...	...	...	142	402	233	500	693	716	621	676
	22	...	...	...	268	473	184	546	635	658	601	589
	24	...	...	...	327	912	167	539	649	644	629	755
C Natural.	23	0.1	4.6	10.2	13	32	212	251	252	311	275	356
	24											
	25	...	...	...	18	39	185	218	215	289	300	341
	27	...	...	...	21	42	150	188	220	257	272	314
	29	...	...	...	20	52	128	178	202	246	248	256
	31	...	...	...	21	57	112	173	199	224	259	309
	33	...	...	...	27	85	104	172	182	267	246	290
	35	...	...	...	38	137	93	121	178	260	286	319
	37	...	...	...	34	160	85	108	168	262	306	326
	39	...	...	...	67	233	85	119	202	252	371	400
A Portland.	13	0.1	7.0	18.0	13	270	366	775	859	1067	892	832
	14	...	...	...	18	303	404	780	891	972	852	781
	15											
	16	...	...	...	22	327	363	602	725	844	806	723
	18	...	...	...	15	383	308	570	723	785	728	724
	20	...	...	...	56	703	225	590	718	760	674	636
	22	...	...	...	52	833	166	554	649	731	643	604
	24	...	...	...	188	918	42	510	691	695	632	574
D Rosendale.	23	2.3	12 4	21.9	22	59	138	177	271	332	284	264
	24	...	...	...	...	78	125	141	264	342	309	310
	25	...	...	...	35	120	150	164	216	308	318	321
	27	...	...	...	49	143	117	116	194	305	345	272
	29	...	...	...	76	166	96	105	164	272	320	267
	31	...	...	...	117	212	72	72	159	270	371	225
	33	...	...	...	115	235	62	71	147	277	379	244
	35	...	...	...	127	400	50	64	112	245	318	315
	37	...	...	...	198	828	59	62	96	...	284	351
	39	...	...	...	260	1057	54	56	85	...	355	364

MEMORANDA.—Results shown are the averages of six briquettes made.

laboratory, in which the crushed quartz or standard sand was used in the proportion of one part sand to one of cement.

Explanation of the results is hardly required; it will be noticed particularly in the natural cements, how uniform and constant is the falling off in strength at the 7-day period, as the amount of fine material increased. This tendency, in the case of C. brand disappearing at the 28-day period, at which time rather remarkable uniformity is found in all the combinations, except the 100 per cent. "Fine;" serious retardation in the improvement of the D. brand, with the addition of fine material in the sand, is noticed between the 7-day and 28-day periods, the mixtures containing over 5 per cent. "Fine" remaining almost latent for this time, three of the combinations showing an actual loss, while four make a small gain, the average gain being two pounds, a rapid recovery is found, however, in these combinations between the 28-day and 6-month periods and it is to be regretted that longer time tests were not made.

A tabulation of the results, excluding the series in which all "Fine" and crushed quartz were used, is herewith given:

	7 days.			28 days.			Six months.		
	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.
C 84	118	62		99	163	70	277	316	221
D139	156	108		198	222	183	336	362	302

The effect of the fine material upon the Portland cement is not so noticeable, even at the shortest period, except in the series with 100 per cent. and 50 per cent. "Fine," and no parallel can be drawn between the test with Portland cement and the results with Rosendale cement using the same combinations of sand.

Cement users are coming to select their cement with more discrimination than ever before. Their increased knowledge of the subject and the more extended use of the material show this to be necessary, and the natural result owing to the struggle for commercial supremacy among the manufacturers will be a better and more uniform product.

The chemistry of cement is an intricate problem and an academic knowledge of it without sufficient practical experience will result in much trouble to the manufacturer and users as well

It is well said that "experience is the best teacher."

MANUFACTURED STONE.

J. C. McClenahan,

The first evidence of manufactured stone, of which we have any knowledge was handed down to us by the pre-historic races. The mound-builders and cliff-dwellers left us large quantities of wares made out of crushed shells, sand and clay, that show a wonderful degree of perfection, the shells gave them an almost pure carbonate of lime, which in turn gave them the means of cohesion; these wares consisting of kettles, water jugs, urns, vases, etc., were made by hand while in a plastic state, and hardened by heat and frequent sprinkling, thus producing crystalization. Not only did these semi-civilized beings show considerable knowledge in the handling of this material, but they displayed much skill in the formation and in the ornamentation of their wares,

Coming down a little farther we find the Egyptians making stone under somewhat different conditions, using a porous lava which contained hydraulic properties, and the basic element necessary in the making of a cement similar to our Portland of today. During the fifteen hundred years or more that the Egyptians mummified their dead they encased the body in a sarcophagus made of manufactured stone. It is pretty definitely decided that at least the upper portions of the great Egyptian pyramids were formed in the same manner, and the massive blocks of stone erected at such great heights were carried there by the pail-full. From slight indications of stratification found in some of the blocks in the lower courses of construction, it is thought that nature had a hand in the work, although it is possible to even show signs of stratification in a manufactured product.

As a further proof that these formations were of man's creation breakages in some of the blocks reveal small pieces of wood embedded in the mass, which pretty fully confirms the above statement. The processes used by the Egyptians in manufacturing their cement, as well as the methods employed in producing stone, belong to the lost arts, although we have every

reason to believe that the Romans rediscovered many of their secrets.

The Roman cement, as well as the Egyptian cement, showed wonderful properties of solidification. The walls and dome of the Pantheon of Rome, that have withstood the destructive elements of time for nearly two thousand years, is one illustration of many that might be cited as to the marvelous skill displayed in producing a "refined concrete" product, in reality, a truly manufactured stone, but in monolithic instead of in block form.

Before going into our modern methods of stone-making, it might be well to look into nature's methods of producing stone, for our own benefit and instruction. On every hand we find massive beds of a substance which received the name of stone. These beds of natural stone reveal to us a large number of different varieties, but all can be classified under a few distinct heads, and they were all formed through the forces of nature in a general way, either by fusion, precipitation or pressure. On one hand nature found a deposit of silica, impregnated with feldspar and mica in a state of igneous fusion; and in the presence of vapor of water, and under great pressure formed the mass into a solid body, which we call granite.

We next come to what we call our soft building stones, which would include limestones, sandstones and marbles. Marble is not always a soft stone, but it is a crytalline limestone, and hence must come under this head.

Limestones were formed either by chemical precipitation or by organic accumulation of marine animals, they having previously assimilated the calcareous matter dissolved in the waters of the ocean.

Sandstones are composed of silica grains of variable size, bonded together under great pressure in the presence of high temperatures, or by some cementing agency, such as carbonate of lime or oxide of iron.

In stones for building purposes, either natural or manufactured, there are certain qualities necessary to be considered, and these are strength, absorption, hardness, structure, fracture, color and chemical composition.

Under normal conditions the changes produced on stones can be ascribed to the action of the oxygen, carbonic acid, nitric acid and water in the atmosphere. In cities, where there is a

larger consumption of coal, other constituents of a far more destructive character can be found, such as acids of sulphur and occasionally hydrochloric acid; these exert an almost irresistible disintegrating influence.

We have gotten a glimpse of nature's method of producing stone, and I don't know that we can hape to improve much upon her handiwork. We may, however, utilize certain elements, combine them together and produce possibly better results than some things in nature that we try to imitate.

Approaching the subject of manufactured stone, I do not wish to refer to it as an artificial product. While we may imitate nature's methods in producing this product, to my mind it is in no sense artificial. We combine certain elements together, cause a perfect union of the elements to take place, and behold the stone.

If we, by some artificial means, produce a product imitating some particular kind of stone, the resultant product might be considered artificial; but to produce a product by perfect chemical combination, I fail to see the artificial side of it. A concrete product should not be made to appear as a granite block, or a marble slab, or an onyx reproduction, but simple an honest cement-concrete stone.

Perhaps the time may come when a beautiful and real granite block can be manufactured, susceptible of taking a high polish, or a fine bristling crystalline limestone can be made, or an elegant transparent onyx produced, but up to the present time this has not been possible, commercially. The elements out of which we make a high-class silicate of lime do not possess the other necessary characteristics.

Touching for a moment the matter of patents that have been granted at Washington during the past fifty or sixty years and the extent of the investigations made along this particular line, I find that over 4,000 patents have been granted on the subject of concrete compositions, concrete block-making, artificial stone-making, and the like, showing the wonderful activity along this line of investigation. From 1850 to 1885 the Germans seemed to take the lead in the number of applications filed in this country on the manipulation of concrete, including formulas, methods, processes, etc., but during the last ten or fifteen years the Americans have taken the lead.

Referring to a few of the earlier patents for processes of stone-making, we find one granted in England in 1832 to an Englishman named Ranger. His method was to mix sand or siliceous material with caustic lime, slaking with hot water and ramming the plastic mass into mold boxes. Later he used the aggregate hot, securing better results; his theory was that the lime would combine chemically with the salica and form silicate of lime. This theory, however, was faulty, as caustic lime and sand treated with hot water or immersed in hot water for any considerable time, do not combine chemically. Frear was granted patents in the United States in 1856. His method was to mix hydraulic lime, sand and gum-shellac; the latter ingredient was added for the purpose of hardening the stone. He used a wet mixture, and when he deposited the matrix in the mold added forty or fifty thousand pounds pressure to the block, but the Frear stone proved to be a failure, and decomposition set in after a few years' exposure to the elements, due to the action of the shellac on the lime, causing it to lose its adhesive power.

Frederick Ransome took out patents in England in 1855 and made considerable stone in London that has shown very enduring qualities. His method was to create a silicate of lime in a mass of sand by first mixing it with soluble silicate, usually silicate of potash or soda, and then immersing the mass repeatedly in chloride of calcium or some other solution capable of decomposing the silicate. By this process silicate of lime is formed and chloride of potassium or sodium is thrown off, giving rise for some time to an objectionable efflorescence, but which eventually ceases when the chemical interaction ends.

Hydraulic cement, chalk, sea shells, coral formations and all kinds of lime substances have been used extensively in various combinations with silicieous materials of different kinds. Steam has been called into play, the vacuum pump has been applied, carbonic acid gas has been introduced as an auxiliary amalgamating agent, the bath has been used very extensively and a thousand and one things have been done in different ways, all in the hope of producing a stone that would rival nature.

Manufactured stone and hollow concrete blocks are two separate and distinct propositions; yet since it exists in the minds of many that they are one and the same thing, we must point out the differences existing between them. Of course about the same

elements enter into the formation of both, but the method of manipulation and process of hardening determines the quality of the finished product. Many false standards have been adopted by hollow block manufacturers, one of the most serious considerations being the matter of cheapness, and in order to work out this result, everything else must be sacrificed. Impossibilities can not be performed in this field of operation. A manufactured stone must possess all the good qualities of natural stone and none of the bad ones. As the old saying goes, "Nothing is perfect," however, the fact still remains that concrete rightly handled is the greatest construction material the world has ever known, and our object should be at all times, in all places, and under all circumstances, to "handle it properly." There is a good deal in these three little words, but the salvation of the stone industry rests upon them.

Much complaint has been made against the architect because he will not adopt the concrete block as it is made to-day, and also because he will not assist in making it what is should be. These demands are outside of the provinces of an architect. He is not in that line of business, and it is outside of his sphere of usefulness, he says: show me a manufactured stone that is presentable to the eye, and one that can be made to conform to my architectural requirements, and I will adopt it in competition with any other material, because I have absolute confidence in the basic element out of which it is made, but I must also have absolute confidence in its appearance—its durability—due to its method of manufacture, and its general adaptability, before I can recommend it to my clients. Gentlemen, when these conditions are complied with, you will find no one more willing to take hold of the concrete stone industry as far as in his power and to push it to the front than the live, wide-awake, progressive architect. I do not offer these suggestions in the way of complaint or criticism, nor do I advocate any special method or process of producing stone. The formation of silicate of lime depends upon the same physical forces of nature that produced natural stone, and the same chemical action that took place in the formation of natural limestones will take place in the formation of manufactured stone if the same elements are placed in position to do so. Calcium carbonate is the basic element in all hydraulic limes, and is found in varying conditions of purity in all limestones, chalk

and marl wherever found. Calcium carbonate silica and alumina in combination are the three essential elements, and, in fact, the chief elements, in the manufacture of Portland cement.

Portland cement will commence to harden, coalesce or unite as soon as it comes in contact with water. Mixed with an aggregate it will do the same thing, and bond one atom or grain to another, to the extent and in the exact ratio of the treatment accorded it. If a body of sand and cement receives an amount of moisture insufficient to thoroughly saturate each atom of cement and bring out its full cementing power, there will remain in the mass a percentage of cement, inert or inactive not only will this be so, but an insufficient amount of moisture applied during the hydro-silicatizataion of the cement—called setting—unequal and inefficient crystallization is the result, and a porous, clammy, dead-looking block is produced, a block unsuited for almost any requirement excepting in the commonest and most ordinary out-of-the-way places. The use of a high class aggregate and a first-class cement, together with careful handling, will improve considerably the class of work being turned out to-day, but the principle upon which its manufacture is based is wrong and cannot be easily righted, owing to conditions at the present time, and while existing methods are carried out it is impossible to comply with the requirements of an architect, excepting in the commonest details, and the change in ordinary sizes, etc. No cutting or fitting can be done, and no complicated design can be followed by the semi-dry process of block-making.

Now to briefly explain the composition of a manufactured stone and the conditions that lead up to perfect result. I will say that a finely crushed natural limestone, standstone, trap rock, or granite, an aggregate that will pass through a 36-mesh sieve, and not to contain over 15 per cent dust, will make a good stone; this aggregate, clean and sharp and thoroughly mixed in a dry state, with cement in the proportion of one part of high grade, well seasoned, Portland cement to three parts of aggregate, and about 40 per cent good pure water, will give the basis for a good manufactured stone.

This composition, poured into a porous saturated mold, where the crystallization of the lime silicates can start, be prolonged and completed, in the presence of ample moisture, and surrounded with a porous saturated blanket, as it were, during

the setting of the cement, and where it can draw onto itself such moisture in such quantity, and at a period needed to develop its highest possible efficiency. This is nature's method and will produce absolutely perfect results; it takes away the cementy look from the product, and produces in its stead that sparkling, life-like appearance of a high-grade natural stone. In addition to the results accomplished, the stone is the same throughout, and can be cut, carved, hammered or worked in any way desired, and every part of it will present the same appearance as any other part and present a pleasing effect throughout.

You cannot force cement to crystallize properly unless you give it the proper treatment any more than you can shoot off a gun a little at a time. Portland cement sets and hardens when it comes in contact with moisture in any form, and setting and hardening are two distinct propositions; though similar in character perform a different function in the ultimate result. The initial and final sets of Portland cement come under the first property, and the long continued and permanent hardening can be classed as the other characteristic. To the completeness and thoroughness of the former depends to a considerable extent the efficiency of the latter and the final perfection of results. Now the density of a stone made under the wet process is due to the fact that while the material is being worked to a creamy consistency, the atoms of cement and grains of sand flow together so closely and hug one another so firmly that no amount of power, however applied, could force a closer union.

Manufactured stone ought to command as dignified a position in the building world as any of the natural building stones found in the bowels of the earth, of a like nature, and there is absolutely no reason why it cannot and will not reach this position. It is not to be expected that it will ever supplant a beautiful piece of polished granite or marble, but when it comes to permanency, and especially to fire-resisting qualities, perfect concrete is a much better article than any marble or granite yet found upon the earth. Good concrete, or, we might say, "refined concrete," such as the perfect stone should be made of, will stand a temperature three to four times greater than any of our best granites or marbles. While I have made the statement that I do not think manufactured stone will ever replace granite or marble, where beauty of appearance is the chief consideration,

I have reference now to its use commercially for outside work, and where Portland cement is the chief constituent in our manufactured product. Very beautiful granites and marbles have been made to resemble the natural product so closely that it is difficult to tell the difference, but as far as my knowledge goes, the material thus far can only be used for interior decoration, as the union and bond of the elements composing the composition is brought about by what we might call artificial cohesion, by the use of chemicals, etc., and, while the bond is permanent to all appearances and may last for many years while under cover, if exposed to the atmospheric elements it will rapidly disintegrate, crumble and decay.

DISCUSSION.

Mr. Harper: I have used an iron machine mold, a rubber mold and a wooden mold. I intend manufacturing this high-class concrete stone, and would like to know whether a sand mold and the use of chemicals in the mold or in the material itself would be advantageous.

Mr. McClenahan: A sand mold seems to produce the best possible product, while iron or wooden molds do not. There is a certain chemical reaction in a sand mold that does not take place in a wooden or iron mold. Moisture penetrates the stone while it is hardening and setting and produces a stone that does not resemble a manufactured product; it is more like natural rock.

Mr. C. D. Watson: It seems to me that a 36-mesh screen, with less than 15 per cent of dust, which the writer advocates, is pretty fine material.

Mr. McClenahan: It is not very fine; six meshes to the running inch gives a very nice granulated material. If you have more than 15 per cent dust, you must get rid of it in some way or get inferior results.

Mr. C. D. Watson: Would you class all material passing say a 100 or 200 sieve as dust?

Mr. McClenahan: Yes.

Mr. C. D. Watson: I notice it has been stated that the stone absorbs the moisture from the sand mold in hardening. Do you actually think that action takes place or that the mold simply retains the moisture and prevents the stone from drying out?

Mr. McClenahan: I have from experience found that the stone will draw moisture from the mold.

Mr. C. D. Watson: How soon after casting do you think that action takes place?

Mr. McClenahan: Possibly that takes place just as soon as the initial set has commenced to take place.

Mr. C. D. Watson: I ask the question for the reason that

we have made a very careful observation of that ourselves and could not determine any absorption.

Mr. McClenahan: As far as the experiments have gone, as soon as cement has set it begins to absorb water.

Mr. C. D. Watson: In other words, you think that when crystallization takes place that the water for crystallization is taken from the sand around the mold and not from the mold itself?

Mr. McClenahan: It will draw some from the mold if it is needed.

Mr. C. D. Watson: You think there is not enough moisture in the cast itself to support that crystallization?

Mr. McClenahan: It is possible that there may be enough.

Mr. Harper: In investigating this question I visited Syracuse, N. Y., where a building was being erected for a university for which the stones were made in sand molds. It was rock-faced to quite a depth by chisels, and had a very good color, but I noticed that there was a yellow color which penetrated possibly about an eighth of an inch or more. It will, however, be a very fine piece of work, and I would like to know to what that color is due.

Mr. McClenahan: I have never seen the building, and do not know just to what extent it has changed color, but if it has changed color it is undoubtedly due to the composition of the aggregate, since no chemicals were used.

Mr. C. D. Watson: Do you think it improves the stone by saturating it after it has been placed in the mold or has been cast?

Mr. McClenahan: I think it adds to the results by keeping the molds very wet.

THE MANUFACTURE AND USE OF CONCRETE PILES.

By Henry Longcope.

Through the courtesy of Mr. Constantine Shuman and Mr. Percy H. Wilson, I am able to present to your consideration a number of illustrations showing the manufacture of concrete piles and the erection of buildings thereon under two different methods.

Piling has an ancient and honorable history, and the prehistoric race of Lake Dwellers, who at one time inhabited one portion of Europe, left traces of their ancient foundations, showing that the pile played an important part in their social economy. It is probable they drove their piles with crude instruments, some distance from the shore, in order to protect themselves from land attacks by their enemies. Through the natural course of evolution the crude idea was perfected by engineers, who saw that wooden piles were subject to decay and the attacks of the teredo worm, as a consequence, sought a material that was more substantial. The first innovation was the sand **pile**, produced by driving a wooden form in the ground and withdrawing the same, the hole being filled with moist sand, well rammed. The next method adapted was to drive a metal form into the ground and, after withdrawal, to fill the hole with concrete; but this was not successful, as it was open to the serious objection that on withdrawing the form, the ground would collapse before the concrete could be inserted.

Still another method was introduced, which consisted of dropping a cone-shaped piece of metal, weight five tons, a number of times from a considerable height, in order to form a hole, which was afterwards filled with concrete. This method never passed the experimental stage. Later a plan was devised to mold a pile, using concrete, reinforcement sometimes also being used. This pile was allowed to stand until perfectly hard, when it was driven in a similar manner as now in vogue. To prevent the concrete pile from injury a drive-head or cap was so arranged as to deaden the force of the hammer blow. While concrete piles

made by this method are effective, yet they are open to several criticisms, such as difficulty in handling and the time necessary to be allowed for the concrete to set hard; in other words, a stock of piles must always be kept on hand at store yard or at the building.

Gilbreth uses a molded taper pile cast with a core hole the entire length of the pile, which is jetted down by a water jet and finally settled by hammer blows.

Still another method is used by Raymond. Under this system piles are usually put in by either of two methods, the jetting method or the pile core method. The water jet system is used only where the material penetrated is sand, quicksand or soft material that will dissolve and flow up inside the pile when the water is forced through the pipe. Water is forced through the pipe, causing the shell to settle until it comes in contact with the next shell, and so on until the desired depth has been reached. The shells are filled with concrete simultaneously with the sinking process, and when necessary spreaders are attached to keep the whole in perfect line with the pipe. The 2½-inch pipe is left in the center of the pile and gives it greatly increased lateral strength. If desired, the lateral strength may be further increased by inserting rods near the outer surface of the concrete. By this method piles of any size up to two feet in diametetr at the bottom and four feet at the top can be put through any depth of water and to a suitable penetration in sand or silt (water sediment).

The pile-core method commonly used for foundation work, consists of a collapsible steel pile core, conical in shape, which is encased in a thin, tight-fitting metal shell. The core and shell are driven into the ground by means of a pile driver. The core is so constructed that when the desired depth has been reached it is collapsed and loses contact with the shell, so that it can be easily withdrawn, leaving the shell or casing in the ground, to act as a mold or form for the concrete. When the form is withdrawn, the shell or casing is filled with carefully mixed Portland cement concrete, which is thoroughly tamped during the filling process.

The Simplex System uses another method, and in it is used a driving form, which consists of a strong steel tube, the lower end of which is fitted with powerful tooth jaws, which close together

tightly, with a point capable of penetrating the soil when driven and also capable of opening automtically to the full diameter of the tube while being withdrawn.

At the same time the form is being withdrawn the concrete is deposited. The form, as carried out in actual practice, is constructed as follows: "Stock length (about 20 feet) of 15 inches outer diameter pipe ½-inch metal is reinforced at the upper end by means of a band of ½-inch boiler steel, 18 inches wide, rolled into a cylinder to fit tighly around the pipe, and riveted to it by means of three rows of 1-inch rivets, eight rivets to the row. The rivets are countersunk and have slightly oval-shaped heads. This band has been found necessary to prevent the upsetting action of the hammer, and its depth, 18 inches, has been found by practice to be the minimum to prevent the buckling of the tube, although it seems well nigh impossible to construct a form which will entirely resist the repeated blows of the heavy hammer, the only solution being to build all of the apparatus of such rugged nature as to reduce the punishment to a minimum. Four large holes are bored 90 degrees apart through the band and pipe, to accommodate the two inch pins which connect the pulling shackle to the form.

The lower end of the pipe is riveted to a cast-steel sleeve having the same inside diameter as the pipe, but of 1½-inches thick metal, making the outside diameter 17 inches. The pipe is turned off true and fits with a driving fit into an 8-inch deep socket turned into the sleeve. Two rows of twelve 1-inch countersunk rivets with flattened heads connect the sleeve to the pipe. To this sleeve are attached two cast steel jaws in such a manner as to permit them to swing freely. These jaws or segments of a true cylinder, the same size as the sleeve, namely, 14 inches inside diameter and 17 inches outside diameter, formed by two planes cutting in at approximately 30 degrees to the axis, and the second at right angles to the first and interesecting a little short of the axis. When brought together they form a clam-shell point, absolutely tight and well adapted for penetrating the soil, but when hanging open they form a true cylinder of the full opening of the pipe.

The interlocking of the jaws binds them together so that they act as one solid piece. The jaws are usually closed together and held by two small tapered pins, or a small clamp, which is

destroyed during the driving and comes off when pulling the form from the ground.

The driving form consists of a stock, length about 22 feet, of large diameter pipe, reinforced with a band and fitted at the bottom with an alligator point. Additional lengths can be easily coupled by means of a band and rivets.

The pile driver used generally is similar to that used in driving ordinary wooden piles.

A sliding purchase cap is arranged near the top of the driver, from which is suspended the pulling tackle, consisting of a quadruple steel block and a quintuple steel fall, reeved with a ⅝-inch plow-steel wire rope, which runs over a single steel block and thence to the engine.

The hammer weighs 3,000 pounds, and the engine is any style of an approved type hoisting engine.

On the top of the driver are mounted three sheaves, the middle one for the one and one-half-inch hammer line and one on either side the bucket line and the rammer line, respectively.

The pile is produced in this way: The driving form is swung up into the leads, with closed jaws. It is then lowered until it rests on the ground and has buried its nose in the soil. The pins are removed, the pressure of the soil holding the jaws together. On the top of the form is placed a steel drive-head with a tenon underneath to engage the pipe, and provided on the top with an oak block to take the shock of the blow. The form is then driven to the required depth; the hammer, with the drive-head attached, is raised to the top of the leads and toggled by swinging out the purchase cap carrying the pulling tackle. The fall is connected to the driving form and made ready for pulling it out of the ground. The rammer is a cylinder of cast iron 6 inches in diameter and weighs 300 pounds. This is lowered to the bottom of the form, and a target is fastened in the rope flush with the top of the form. The rammer is raised half way up in the tube, and a bucketful of concrete, which makes about 4 feet of pile, is hoisted in a bucket having a falling bottom, and emptied down the tube, striking the bottom with considerable impact. The rammer is lowered until it rests on the concrete, which would show the target about four feet above the top of the form; the form is pulled up until the target on the rammer line is one foot above the top of the form, which indicates

that the jaws have opened and the concrete has passed through, with the exception of a one-foot head of concrete left in the form to prevent any particle of soil from getting into the concrete; the rammer is raised and let fall frequently to insure perfect ramming; then the rammer is raised half way up in the tube as before and a second bucketful of concrete is emptied, and the process is repeated until the hole has been filled and the form withdrawn.

The concrete used consists of one part Portland cement, 2 1-2 sand, and five parts broken stone, graded.

A modification of the method just described is to fill the form with the required amount of concrete, sufficient to make a complete pile, and a ramrod, which is merely a piston head with a rod fastened to it, upon which the hammer is lowered, but not struck; the form is then pulled and the hammer gradually settles showing that the concrete is spreading out below as the form is withdrawn, or in other words, filling up the entire space previously occupied by the form.

In order to prevent voids another precaution is taken by furnishing the men with comparative tables, indicating the amount of concrete which should be inside the form, in order to make the required length of finished pile. If on raising the form, the concrete should slop over, it would show that voids existed, and therefore the personal equation would be present here, as it is in all other operations.

In certain conditions of soil, such as deep fills of rubbish, cinders, or light loose materials, a cast iron point, generally of a similar shape to the alligator point, is used. There is no sleeve or jaws whatever on the end of the form, there being nothing but the plain length of pipe. The cast-iron pipe is located on the proper center, on the ground where the hole is to be driven, the pipe form is lowered over this point and driven to the required depth, the method of withdrawing the form and filling is exactly the same as the method before described for alligator points, except in the case of the cast-iron point which remains in the ground as obviously it cannot be withdrawn.

It is so evident that concrete is vastly superior to wood in the construction of piles that it is almost superfluous to mention the points of superiority. Concrete is not subject to rot or the ravages of the teredo worm, neither can the pile constructed of

concrete be destroyed by fire and no cost is attached for repairs. While it is not possible to give accurate statistics as to the life of a wooden pile, as it varies so much under different conditions, yet we know that in some cases they are rendered worthless in a very few years, especially when the material which surrounds them is composed of rotted vegetation, or where the pile is exposed by the rise and fall of tides. It is also impossible to state the exact cost of a concrete pile, as it varies also according to conditions. Ordinarily speaking, a concrete pile will cost from 1 1-2 times to 2 times as much as a wooden pile, but in order to illustrate where a saving can be made, the following extract from a letter is given relative to the piles at the United States Naval Academy at Annapolis, Md., viz:

"The original plans called for 3200 wooden piles cut off below low water, with a capping of concrete. To get down to the low water level required sheet piling, shoring, and pumping and the excavating of nearly 5000 cu. yards of earth. By substituting concrete piles, the work was reduced to driving 850 concrete piles, excavating 1000 cubic yards of earth and placing 1000 cubic yards of concrete."

In the work mentioned, the first estimate for wooden piles placed the cost at $9.50 each, while the estimate for concrete piles was placed afterwards at $20 each, yet the estimate based on the use of wood piles aggregated $52,840.00, while the estimate based on the use of concrete piles was $25,403.00, or a total saving in favor of concrete of over $27,000.00.

One question which arose in my mind when I first started my investigation, was, whether the pile when completed was one solid mass or whether it was full of voids or soil. In several instances the piles were uncovered to their full depth and they were found to be perfectly sound in every particular. By surrounding the operation with the safe-guards provided, it is almost impossible to make a faulty pile. The concrete is made as wet as good practice will allow, constant ramming and dropping the concrete from a considerable height, all tend to the assurance of a solid mass, then the target on the ramming line or the introduction of an electric light into the form, shows what is being done at the bottom of the form.

In a paper of this character it is almost impossible to cover every point in detail and it is not intended as such, but merely

to sketch in outline the observations made from time to time, for this unique method of using concrete and if the spirit of investigation has been fostered or your faith stimulated my purpose has been fulfilled.

THE USE OF SALT IN CONCRETE SIDEWALK CONSTRUCTION.

GEORGE L. STANLEY.

After an experience of fourteen years in concrete work, I feel as though I was still a learner and hope during this session of our Association to still be a learner, and if my suggestions, as the result of my experience, are of any benefit to my fellow craftsmen, I would not have you give me alone the credit, but to many who have been making laboratory and practical tests in concrete work in different parts of the United States and among those I would make mention of, is the honored President of our Association.

The fact that it is often necessary to do considerable work in freezing weather makes it desirable to be able to lay and care for the work in such a manner that it may not be damaged by frost. The foundation should be porous and as well drained as possible, as freezing the first twenty-four hours after the walk is laid is liable to expand the ground under the walk, which will crack the walk before the hard set takes place. The use of what salt can be dissolved in the mixing water will prevent the walk from being scaled or cracked by the expansion of the frosted concrete in thawing.

Should the sand and gravel be very wet, salt should be spread in batches with the cement so as to be mixed with the sand and gravel the same as the cement. In case this is done the mixing should be continued considerably longer so as to dissolve the salt as much as possible before wetting, and after wetting the batches should be turned once or twice extra as prolonged mixing increases the strength of the work.

In cool or freezing weather only water enough should be used in wetting so that the work can be floated and troweled and covered very quickly after the concrete is placed in the molds. The setting takes place slower in low temperatures, but sidewalks can be given to the public for use from one to four days sooner when salt is used.

The safest manner of caring for the walk during the hardening is to cover with sawdust, planer shavings or earth and to cover the whole walk with canvas or other covering so as to keep the walk as dry as possible; this will hasten the hardening and prevent the frost from affecting the work.

I have laid walks as late as December 20th and the past season about 9000 sq. ft. was laid after November 1st. I use about 10 per cent. more cement in cool or frosty weather so as to insure strong work. Walks in which I have used salt during the last seven years are fully as satisfactory as those laid without salt.

As to the effect of salt on sidewalks, there may be a difference of opinion among concrete experts, but there is a general agreement that, if properly used, it will assist in preventing injury by frost and if there is any injurious effects the benefits from its use leaves the walk in a much better condition than it would be if not used.

Most tests are tensile and laboratory tests, and the briquets are not usually stored on the ground as sidewalks are laid, which does not show the effects of different atmospheric and weather conditions on the concrete; but some tests have been made by engineers in charge of government and other work which are very instructive.

In December 1904 I molded about seventy-five 3-inch cubes and in one-half about 15 per cent. salt was used for the purpose of determining the effect of salt under different atmospheric conditions. Those mixed with salt water were stored the same as those mixed with fresh water. One-half of the cubes were placed in the open air on the ground before initial set, the temperature of the air being about 10 degrees above zero. Of course those mixed with fresh water were frozen solid, but those mixed with salt water showed no effects of frost when the temperature was 10 degrees above zero, except the hardening set was very slow. The other half were hardened, and stored in a damp cellar on the ground until packed for shipment.

The cubes were all carefully packed, marked and shipped to Case School of Applied Science, Cleveland, O., December 15, 1905. I was assisted by two of the '06 engineering class in breaking the cubes. The records of the breaking of the cubes have been tabulated and I leave a copy and this paper with the

Memorandum of Cubes Broken at Case School A. S, by A. G. Anthony and B. E. Pheneger. Class 1906. Condition of Sand and Gravel, Moist. Amount Water used, about 18%. Per cent of Salt to Water about 15. Moulded December, 1904. Broken December 15th, 1905. Cubes 3x3x3 inches.

Initial Marks	Where Kept	Cement S. & G.	Ultimate Strength in lbs. Fresh Water	Mean Average Fresh Water	Ultimate Strength in lbs. Salt Water	Mean Average Salt Water	Fresh Water Over Salt
S. O.	In. & H. set 20° Rem of year in open air uncovered.	Top Coat 3C:5S Bot. Coat 1C:5G	Compare with S. O. I. to show effect of salt on concrete.		8600 10000 12000 15000	11150	
S. O. I.	In. & H. set in dry basement Tem. 40° Rem of year covered in moist cellar.	"	Made from the same brand of cement and moulded the same as S. O.		9000 11400 14000 10600 13200	11640	490 in favor of moist cellar
S. A. O.	In. & H. set in air about 10° Rem of year outside air uncovered.	"	Compare with S. A. I. to show the effect of salt on concrete.		18000 16800 19000 17400 19000	18040	
S. A. I.	In. & H. set in basement Rem of year in cellar uncovered.	"	Same brand cement and moulded like S. A. O.		20000 13000 13400 16400 11200	14800	3240 in favor of outside air.
F. A. O.	In. & H. set Tem. about 10° Rem of year outside air.	"	7000 10000 7800 9600	8600	Compare with F. A. I. to show injury by freezing before initial setting.		
F. A. I.	In. & H. set in basement Rem of year in cellar uncovered.	"	13000 14000 12000 19000	14500	Same brand cement and moulded like F. A. O.		
E. G.	In. & H. set in basement 40° Rem of year covered in cellar	3C:5S	31800 25800 24600 20600	25700	Compare S. A. O. & E. A. O. to show benefits from using salt in water used to mix concrete.		
E. O.	In. & H. set in basement Rem of year in outside air.	"	21000 30000 18000 30000	24750	Comparison of E. G. & E. O. show practically the same strength of concrete as a whole		

secretary for such use as may be thought best in the interest of our Association.

Of those stored in the cellar, there was but little difference between those mixed with fresh or salt water. But of those stored in the open air outdoors there was considerable difference; about 50 per cent. in favor of those mixed with salt water, and what was the most surprising was that those mixed with salt water and stored on the ground out doors showed about 22 per cent. stronger than those mixed with salt and fresh water and stored in the cellar.

These cubes all contained the same proportion of cement, sand and gravel, and were of about the same consistency, so that the place of storage and atmospheric conditions were the only influences which could cause the differences in strength.

The conclusions to be drawn from these tests are that 15 per cent. of salt can be used in the mixing water without injurious effect on concrete three inches thick and placed on the ground. That salt will prevent injury to concrete by frost at temperatures about 10 degrees above zero. That concrete without salt in the mixing water will be more or less injured by frost if laid in freezing weather. That if there is no frost in the material used and if properly cared for, concrete walks can be laid in freezing weather and be strong and durable.

DISCUSSION.

Mr. A. N. Pierson:—I would like to ask on what basis this 15 per cent salt was added, whether it was 15 per cent of the water or the total aggregates?

Mr. Stanley:—It was added to the water, 15 per cent by weight.

Mr. Seafert:—I would like to ask Mr. Stanley if he ever used limestone with that mixture of 15 per cent. salt?

Mr. Stanley:—I have not used limestone at all. These tests were made with clean, sharp lake sand and gravel such as we get on the shores of Lake Erie, and with which we make our best walks.

Mr. M. S. Daniels:—If the cement block is made with a proportion of salt to keep it from freezing will it not in humid or wet weather show moisture which is drawn through that block by the presence of salt and which would not be shown in one which is made with pure water only?

Mr. Stanley: I cannot answer that question, because I am not a cement block maker. The appearance of sidewalks laid with salt is different from those in which salt is not used. It seems to tamp much firmer, and consequently they look much darker. The snow and ice will not show on them as quick as where the salt is not used.

President Humphrey: As regards salt, I think it is perfectly true that its use in concrete has the effect of drawing moisture to that concrete, salt being hygroscopic. At times when the surrounding air is dry, the moisture in the concrete is brought to the surface and with it soluble salts causing efflorescence. The reason it is not particularly noticeable in the sidewalk is the fact that the people walking over it rub off any efflorescence that might show, while in the block it would tend to draw out the salts that are in it and produce probably a rather greater efflorescence than would be the case normally.

Mr. Daniels:—Will a block treated with salt in a wall have any different appearance than a block made with fresh water? That is, in the case of humid weather, will it show that it is

moist by being of a darker color if it be placed alongside of a block made from fresh water?

President Humphrey:—That is rather a hard question to answer, and I should say as a result of my experience you would probably have a little greater efflorescence. The philosophy of the efflorescence is this: that if your block is quite porous driving rain storms force the moisture into the block. When the dry period comes then the moisture is drawn from the block and brings out with it the salt which it has dissolved. After a time the soluble salts are to a certain extent taken out of the block and if the block is washed then the efflorescence on the surface is generally less. It should be borne in mind that cement is soluble in water so that you will always have a certain quantity of efflorescence. To illustrate this point further I would state that in Philadelphia there was a conduit built which was to take the filtered water from the Torresdale plant and deliver it to the pumping plant about 3 miles away. There were a number of fissures in this wall through which the soil water flowed because the height of water in the river was greater than the conduit, so that there was a pressure of water on the outside. When they came to clean out this conduit they gathered up some 600 barrels of cement which was simply hydrated lime. It rather impressed people that there was something wrong with the cement. There was nothing whatever wrong with the cement. It was simply the normal action of the water on the concrete exposed in these cracks. The efflorescence is due to the same cause. The cure for this, of course, is to make your blocks dense, reduce the porosity thereby preventing the penetration of the water into the heart and preventing the salt from coming to the surface.

Mr. John Driscoll:—Clay has been recommended here in sand. We have used bank sand with 20 per cent. clay and made blocks of that, and sand alone. It is a pretty good quality of graded sand and the blocks we made from it with the same cement we formerly used showed more efflorescence than those made with crushed stone and other sands that we have used. Now, is there not something in the clay that is used that causes greater efflorescence than clean sand?

President Humphrey: The effect of clay, as I explained a little while ago, depends upon the possible combination of that

material. The impression conveyed was to take clay and mix it with the sand. The question is whether a bank sand, which by virtue of its position contains clay, is suitable for use. A sand which contains normally a certain percentage of clay if it does not occur in puttylike or lumplike condition may not be injurious, but may be a good thing. It is usually not of a sharp granulated character, and if it is of a flaky nature it interferes with the mixing and with the bond that should be produced between the sand stone and cement. Clay being hygroscopic, it will draw more moisture to the stone. It is like salt, as I have explained before.

TOPICAL DISCUSSION ON SIDEWALK LAYING.

President Humphrey:—Our session this morning is to be devoted to the question of sidewalks and the relation of the aggregates, cement and other materials which are used in their construction. We are going to discuss failures such as we have seen here in Milwaukee, why pavements crack, the cause of hair-checks on the surface, and why they disintegrate and go to pieces. This is the earliest form in which Portland cement was used in this country. Many of you will recall that for a great many years they used natural cement. The results in the early years of the industry were disastrous. Pavements failed everywhere and did no little in retarding development in this line, but nevertheless it has developed very rapidly and there is hardly a small town in the country now that does not have some miles of concrete sidewalk, and I think, generally speaking, the knowledge of how to lay a good sidewalk is pretty thoroughly distributed. In the beginning a man naturally makes some mistakes, but he learns how to do better, has the accumulated experience of a number of other pavement layers, so the result is a series of good pavements around the country. In a pavement you must have your sub-base and that of course must be of a character that will drain away moisture, so that the action of frost will not buckle up your pavement, and cause it to swell and crack. If for that purpose you have not a good gravel or a soil that will drain readily it is practice to put in cinders; and where, as in the city, there is a narrow line of earth on either side, it is customary to put the sub-base up around the edge to a certain extent so as to prevent the action of frost in breaking the edges of your pavement. Then of course you must have your concrete base, which may be of a proportion which is determined largely by the character of the materials that you are going to use, and then on top of that there must be a wearing surface. I am not going to give you standard specifications for making a pavement because this section on concrete during this year is going to report a pavement. Of course what I have related to you in reference to a pavement

is a very simple process, but in the making of that pavement and making it good and durable, so that the wearing surface is good, so there are no cracks, so expansion is taken care of there is a whole lot of detail. People wondered why pavements around Milwaukee are all cracked along the edges. We found they had been laid in a continuous sheet and as there was no provision for expansion it made lines that looked like cracks, but which only go in perhaps a quarter of an inch. They do not go into the body of the concrete. Concrete expands and contracts under the action of temperature, and in order to take care of that we must have room for that expansion to take place. If your pavement is solid, that expansion is going to raise it up because if you have two thick ends, as you have from the house to the curb, for example, the curb is either pushed out of place, as I have seen or else the concrete is lifted up bodily; and in time that moving up and down of the pavement will eventually crack it. So it is customary to have it cut straight through so that expansion and contraction can take place without detriment to the appearance of the pavement. I am going to ask Mr. Stanley, who has had a great deal of experience in sidewalk work, to tell us briefly some of his experiences, some of the difficulties he has encountered in the years that he has been laying sidewalks.

Mr George L. Stanley:—I wish to ask the President when the first sidewalk of concrete was built in the United States?

President Humphrey:—In Philadelphia around the City Hall they claimed to have laid the first pavement. One of the earliest forms of construction, under what is known as Stewart's patent. was put down. That patent provided for a steel bar to reinforce the concrete surface. My recollecion is that the earliest pavements were laid in the early eighties.

Mr. Stanley:—Along the shores of Lake Erie where there is sand and gravel, there have been walks laid about 25 years, which are in good condition. I have taken up and relaid some of those walks that have been laid 17 years, and in relaying broke them to get them to a new line, and to lay up against trees. The concrete was good solid; the top coat did not break off from the bottom coat, which you could split in two in order to clean off the bottom for retamping. Now in regard to the difficulties that we experienced. Our great trouble has been cracking due to frost. To have a stone crack from top to bottom in a zig-

zag line does not usually lessen the concrete's resistance to wear, but if there are several cracks all through, and it gets out of place, that stone is soon out of service. We started in northern Ohio with a paper joint. The paper came within about a quarter or half an inch of the top of the walk. In a few years we commenced using a sand joint. We cut down to the sand, put the sand in the joint and then troweled it off smooth. That would often crack back in line a little bit by the action of frost, but it made a good joint; but there was an expansion with that kind of joint that we did not like. The walks would often expand and buckle; turn right up so that we would have to take the stones entirely out and cut them back, sometimes half an inch, in order to relay them so they need not buckle again. That was objectionable. Then the use of the parter came in and we have been using it there about 5 or 6 years. The parter was used before but little because it did not cut through after running out. We cut through to the sand after using the parter, which makes a complete separation. In case of expansion and in case of frost it will come up and settle right back to its place again. That is the best joint we have found. We have all sorts of soil. We have the best clay and the best loose loam and sand, coarse sand and coarse bank gravel to put our walks on, so that we have had all sorts of experience. As to those specifications I am in hopes they will be gotten out this year and will be clear and such as any contractor can use and use intelligently to make a walk that will stay in place. The amount of cement that should be used for the aggregates is something about which there may be a difference of opinion, as it would depend largely upon the material used with the cement. A coarse gravel, say from one inch down would need very much less cement than a finer gravel. My great trouble is to get the coarse gravel at all times. Sometimes it will be fine, so fine that it nearly approaches what we would call coarse sand. In that case it is necessary to use a great deal more cement. We have settled this so that no matter whether it is coarse or fine, we put in about so much cement anyway. Then we have enough for the finer as well as for the coarser.

Mr. S. W. Hoffman: How do you place sand in the joints of your subwork?

Mr. Stanley:—The best method we have found in making a sand joint is to lay a 2 by 4 right between the strips, and cut

through with a spud, about 6 in. wide and 1-4 in. thick, with a blade 4 or 5 in. long; 5 in. is better an then cut right down through the whole length of that spud. The spud should have what we call a "D." shovel handle on top. Cut through and make a clean, open cut about 1-4 or 3-8 in. wide. Then pour it full of dry sand or if you have not dry sand, work in the wet. It must be worked down. Pour that full of dry sand, then scrape the sand back clear from that coat, scatter it evenly all over the bottom coat, so it will make no partings whatever at the ends, cut it back well in order to avoid breaking the corners at the ends. That is the best way we have found of putting the sand in and making the open sand joint.

Mr. James J. Farley:—Don't you find that you have a somewhat loose top where you make sand joints in that way, due to the fact that your men get it scattered over the top of the concrete? I have been in the business for ten years and at one time used the sand joints, but here of late we cut our concrete on top altogether, that is cut it once; spread our top, and then cut our base and top all at once. We only cut it about 2 1-2 in. deep on a 4 in. walk. Don't you find that where you put the sand in the joint before putting on your top, that you have more loose top right around the joint?

Mr. Stanley: I would answer that yes and no. Of course you note what I said about scraping back the sand clean from the sand joint, leaving it just clean concrete and scattering the sand over so as not to have that looseness. We use our concrete wet enough so that we can finish the walks 15 or 20 minutes after the top coat is put on, if we wish to, and have it firm, not flexible or limber. Where the top coat is tamped on firmly we have no trouble whatever with the top coats not sticking to he bottom coat.

Mr. E. Kenney:—I live in western Iowa where everything has to be shipped, and I have had some disastrous failures in trying what is called chip rock. I would like to know the opinion of this convention on the advisability of making a pavement entirely of the same sand substance.

Mr. Stanley: About a year and a half ago our city engineer wrote a set of specifications for single coat work. There were some experimental walks put down just before this and I put down walks where we used very coarse sand for the top coat, but

it would be something like single coat work if they had only put in enough cement. But you all know that in single coat work you could not afford to use cement enough in 3 or 4 in. of walk to make the top wear smooth as it ought to.

Mr. J. J. Farley:—Where I have been working is a black loam. We have from 2 to 4 ft. of black loam, and we have found that where we cut our joints before we put the top on in the freezing and thawing some blocks will rise up as high as half an inch, and will not settle back. As I said before, we only cut about 2 1-2 in. that leaves the particles of concrete binding on each other. The ground freezes from 2 ft. to 40 inches deep. The walk is bound to rise where it freezes, and in leaving this part uncut the whole walk must settle altogether, but where we cut the joint through and sand it, one block will rise up probably 1-2 in and when it settles they don't settle together.

Mr. William Bell: It is my experience with cement walks that the joint wants to be reasonably divided so that in case of breakage it breaks in the weakest point, and that a little bit of binding together there will keep the blocks more even.

Mr. Kenney:—That has been my experience.

Mr. Mankedick:—If the filling underneath is drained right it will never rise. I have always used sand joints, and haven't a bit of trouble with them.

Mr. S. W. Hoffman:—Where we have a good many different gangs out laying walks, and cannot give our personal attention to it I have found a good deal of trouble with the edges sometimes working up loose, so we have decided to cut our joints and fill them with the top coat mortar, and then cut clear through to our cinder foundation, and we have had very little trouble since we adopted that method.

Mr. H. O. Van Meter: I operate in central Illinois. We have a black loam with clay subsoil. We believe in dividing the blocks clear through. If it is a walk 4 in. in thickness we will take 4 in. siding and set that every 4 or 5 ft., with the bevel downwards, put in our concrete and tamp it. We make our top coat very wet; use crushed stone exclusively because in our country gravel cannot be obtained very easily. Then we pull out these pieces of siding and tamp lightly. When the top coat is being troweled and ready for the finishing coat we take the pointing trowel and cut directly through the top coat. In that way we

find we have an entire separation. If a square is to be replaced we can replace it without damaging the jointing. We have never had any trouble from one block being lifted up above another. The usual specification there for the cinder fill is 6 in. But we have built miles of walks with only 2 or 3 in. of cinder fill underneath them, and these walks have stood just as nicely as those where there was one foot of cinder fill. In the matter of drainage, I think if a man uses judgment in taking care of the surface drainage that is just as important as digging a deep trench and filling with cinders which will be an absorbent for water and sometimes causes damage, if you have a sudden freeze after a big rain in the winter. I think that a little fill of 2 or 3 in. in that kind of soil is just as good as a foot.

Mr. Stanley:—The experience of this gentleman shows conclusively that it is not necessary to put in a foot of cinders in all places, although I would hardly want to agree with him that it was not necessary in some places.

Mr. Kenney:—The specifications in Iowa call for 1 in. of sand only on black soil. In places where there was difficulty they advocated four inches of cinders.

Mr. J. J. Farley:—I have been working in a town in Southern Illinois during the last three years. In the low places they never put in over four inches of fill, while on high land they just level off the ground for me and I put the walks right on top of the ground, and I have found that we are never bothered at all where we don't cut our concrete through. The specifications call for only about 1-2 in. of top. If you are not particular in cutting your joints you are liable to crossways of the joint in the concrete and perhaps miss it by 1-2 in. Then you may have two cracks in a year or two, one where your joint ought to be and one where it is. I have found that where I cut the base and top together I have had better success, and have no cracks at all.

Mr. Hoffman:—I did not mean to say that I cut them separately. We fill our cut in the base of the walk with the top coat mortar, put our top coat on and have marks on either side where the line is to be, and then cut directly through, clear through. The rich mortar of the top has been worked down into the cut so it will bind the top with the concrete, and thus prevent the danger of the edges turning up or working loose.

Mr. Stanley: Cutting through the bottom coat is compara-

tively easily done if the sand and gravel is suitable. If the gravel is what is called round grain, the spud will dodge it, and the concrete is easily cut through. But where broken stone is used, or where the gravel is more or less angular, it is very difficult to cut through. I would like to know the experience of those present in using steel separations instead of cutting with the spud, as is often necessary with border stone of certain sizes. Have any of you had any experience in the use of pieces of steel a quarter of an inch thick? With broken stone they are perhaps better than using a spud.

Mr. Hayes: I use a steel bar to make an expansion joint about every 25 to 50 feet, leave the steel bar in when I go to dinner, withdraw it when I come back, and finish right up to the bar. I believe in cutting partially through. The specifications in Kansas City are to make alternate blocks, but I find the trouble with alternate blocks is that one block will rise higher than the other and cause stumbling. Take a good sized brick mason's trowel, and cut the blocks clear to the point. Of course the bottom of the cut is not as wide as the top. Then go ahead with the top coating, 1-2 to 3-4 inch; spread that over and block it, go back over it again and cut with the same trowel. We use what is known as mine tailings, a clean, sharp granite stone, from a flint lead mine. We use a 2x4 form. We put in 3 1-2 inch of that concrete, tamp it down and put on a 1-2 inch top, take the brick trowel and lay off the stones 4 or 5 feet long, or whatever we want them, cut our concrete, take a straight edge and groover, and immediately follow them up, using the groover along with the finisher. After one groover leaves, another comes and finishes it, and while he is finishing runs the top together again, and points up the joints. I find we have no trouble because of buckling up in the winter from expansion and contraction, caused by freezing. The expansion joint is very necessary in our country, and we must have them at least every 50 feet. I don't believe in alternate blocks, as I think they draw continuously together at the bottom. Our specifications call on a cinder foundation from 6 to 8 inches deep, but I believe it is not necessary as it depends altogether on the drainage and the location.

Mr. Stanley: How deep does frost go in Kansas City?

Mr. Hayes: Anywhere from a foot to 18 inches.

Mr. Stanley: As you get further north the frost goes all

the way from 2 to 6 feet, and in clay soil where there is an expansion of 6 feet everything is thrown up. I have seen in the city of Ashtabula, rock edge up 5 or 6 inches. No matter what kind of a joint you have or how it is made those walks are going to rise up, and if there is no joint there is going to be one made by a crack. In that case it is necessary to have your walks cut loose from top to bottom and have a paper or sand joint made in some way, so that each stone can rise up independently of all others. If you don't the stone is going to crack in that great expansion. But further south where the frost does not go over 1 foot or 18 inches, it is different. The further south you go the less particular you will need to be in cutting the sand joints, but the further north you go the more important they become. I have had walks laid where they buckled up 6 inches with frost and yet settled back in the spring so that you would not know that they had ever been displaced. They never would have done so if the joints had not been cut loose from top to bottom and sand joints used.

Mr. Farley: The specification of Los Angeles, California, compels the use of a jointer and a cut one-half inch deep. The base is not cut at all. Of course there is no frost. The city engineer sets the grades for a 3-inch walk, 2½-inch of base and a ½-inch top, and the specifications include no filling at all on curb, gutter or sidewalk. I have been using what we call lead chats from the lead mines. It runs from the size of a grain of corn down to a grain of sand. We screen our top out of that and use the rest for base, and we find that in mixing a 1 to 6 base we have no cracks at all and a 1 to 1½ top. We find this material is the finest we can get, because it is all about the same size and you don't have to mix anything with it except your cement. It is handled with water and comes from depths of 500 to 1000 feet, so it contains not a particle of dirt.

Mr. John Buehler: In my experience during the last 6 years the ground sometimes froze to a depth of 6 feet. Four years ago all the waterworks froze, and they were 6½ feet in the ground. I used to make joints with tar paper, but that one winter settled back and about 1-8 inch chipped off because the joints were close together. Then I started with sand joints, laid in a 4-inch strip as a partition, and when I had my concrete in place took it out and filled the space with sand. Taking a little fine

mix I put that over it, being very careful not to leave any sand on top, and then put on the top coat and covered that too, and I haven't had any bother since. The last two years depending on the character of the walk, I used 5, 6 or 7 3-inch strips instead of a 4-inch strip as I had previously done. We leave the strips in until we come up with the finishing coat, and just before we get there one man goes ahead and pulls them out, and we run our top coat over. We have had no bother yet. I had some walks which seemed to rise up, but they settled back in place.

Mr. D. J. Hamill: What would be the depth of concreting and what is the nature of the footing?

Mr. Stanley: Our specifications, of course, are not always followed very closely. A sidewalk contractor often makes his own, and I think that is wisely so, in many cases. The amount of cement to be used in the aggregates, is a matter of judgment. The thickness of a walk is a matter of judgment, depending upon the places where it is to be used; if it is to be used for heavy work where teams are likely to drive over it with heavy loads the walk should be at least 4 to 4½-inches thick, the bottom coat should be 1 to 4½ and 1 to 5. There is really no set of specifications that would apply to all places where sidewalk is laid. The best idea is to get in plenty of cement, for the sand and gravel that you use, and to tamp your bottom coat very firmly and hard so it will be well compacted.

Mr. Hamill: Do you consider a sand filling of say 1½-inch in depth equal to 4 or 6-inch of cinders?

Mr. Stanley: I would say so. Of course if it is a firm clay bed, a good firm bed, just enough sand to level off the mold is all that is necessary. Anything more would not amount to anything for the frost will go more than that little half inch. If you are going to put in cinders or sand or loose gravel or anything that is porous, it should be deep enough so that the frost will not go down through it. Of course it helps if it is thinner Whatever thickness it is it all helps, but when it comes to what is necessary to make a good serviceable walk and have the walk stay in place, I myself don't think it is necessary to put in over from ½ to 1-inch; just enough to dress your mold.

Mr. Hamill: The point I raised was, is sand as good as cinders for a filling? Will 1-inch of sand equal 4-inches of cinder filling?

Mr. Stanley: That is a comparison I can say nothing about, but of course the sand is the best for dressing a mold.

Mr. H. J. Jaxon: In Chicago there is considerable difficulty in getting filling. The cinder production of the city at times is not equal to the task of providing a proper foundation for concrete. Now the question that I would ask is this: Has any member of this association had any experience or has experimented with what they call gumbo or burnt clay as a substitute for sand or cinders as a foundation for concrete in sidewalks. I ask the question that it may go into the record and may elicit a response later on from some gentleman who may not be here.

President Humphrey: The chair would like to say that he understands that this material is merely burned clay, and the price at which it could be purchased in the market is such as to prohibit its use for purposes of that kind.

Mr. H. O. Van Meder: I would like to know how this gumbo is burned.

President Humphrey: The chair's experience with gumbo dates from the exposition at St. Louis, and those of you who were fortunate enough to visit that exposition will recall the red paths around the exposition grounds. They were laid with gumbo. The clay was dug out, put into ovens, burned, and was then broken up. The clay was sufficienty fusible that it baked very hard at that temperature. But I understand that the market price of that gumbo made it cost as much as crushed stone, and it also has the property in wet weather of softening somewhat and becoming quite sticky, which of course would be an objectionable feature for a sub-base, because any material which would be hydroscopic, that is, that would attract water, would be undesirable for that purpose.

Mr. Stevens: A number of years ago in laying a walk at Jackson cinders from a chemical works were used as a filler and in a few weeks the walk disintegrated and turned white in spots. A sample of it was sent to Ann Arbor for analysis and it was found that the sulphuric acid from the cinders had destroyed the walk. In another case of my own experience the walk had set just enough so that another rain would deface it, so we covered it with oak sawdust. It rained all night and when we uncovered the walk we found it had disintegrated and in places had turned yellow. The tannic acid from the sawdust had destroyed the

cement. I understand though that an attempt was made in Philadelphia a few years ago to use sulphuric acid in sand molding, and that it destroyed the face of the stones and they all were condemned.

President Humphrey: Are we to understand that this oak sawdust on the surface of the cement in the course of one night destroyed the cement?

Mr. Stevens: No. we didn't take it off the next morning, I think it was the second day.

President Humphrey: What was the evidence that the cement had been destroyed?

Mr. Stevens: There was a very thin skin of it. It turned yellow, though not much more than a sixteenth of an inch, just enough so that we had to replace it. The surface seemed soft when brushed. We left the walk in that condition for quite a while. I would say it was soft for a week, after that. It did not destroy the whole surface, but only in places, especially along the edge, presumably where there seemed to be more water.

President Humphrey: It is rather a unique statement to the chair. The chair would not want to doubt the personal statement, but he cannot conceive how tannic acid could produce such a result in such a short time. I think you might find that there was some other cause than the tannic acid. I have covered cement many times with pine sawdust and never had any trouble.

GENERAL DISCUSSION.

President Humphrey: I am going to make a few remarks which I hope will not be amiss. We have had a great deal of discussion as to the strength of materials of construction, involving, of course, the strength of concrete block; and there was a discussion here the other day, if you remember, as to the value of air space, and the regulations of one of the cities, were read, as to how much strength the blocks should carry. It is certainly true that the concrete block is in competition with brick and stone, and that as far as the building is concerned, it is not a question of the kind of material of which the wall is composed, but what load it will support or carry. We have also heard a great many comments as to the character of this new material which we are creating, which has been designated artificial stone. When we look at the matter chemically, we find that the ingredients used in a hollow block are just the same as the ingredients that are found in a great many other natural building stones; the only difference is that the natural stone has taken a great many centuries to acquire strength. Now, if you give this hollow block or artificial stone the same length of time, then you could reasonably ask for the same compressive strength that you would get out of any other form of stone. We have as an example the very inferior material which the Romans, Egyptians and other ancient races used some two or three thousand years ago, which has acquired a great deal of strength. If such inferior materials as those the ancient people used will acquire such strength then we may reasonably assume that a material that is properly made and does not contain within itself the elements of its disintegration will in time acquire that strength.

There is, for instance, the requirement asking for a minimum of 2,500 pounds per square inch. In some forms of concrete, this, of course, is possible within a reasonable length of time; but in others it is impossible. The requirements for strength in concrete depends greatly upon the proportions and the richness and a number of other things, and you cannot expect to get the maximum strength immediately. I think, however, that to a great

extent the manufacturers of the artificial stone, are particularly at fault in agreeing to something which they cannot fulfill. There is a tendency of the concrete block maker to rush in and guarantee things which he cannot reasonably fulfill.

Now, as to strength of this material. A concrete of 1, 2 and 4 after 6 months may acquire 5,000 pounds per square inch. That is a very strong concrete, if you get 2,000 pounds out of a 1, 2 and 4 concrete in 28 days, you are doing very well. You can get it in 7 days, but it will depend entirely on the climatic conditions, and the time of the year. In winter-time it is more difficult to get the strength than it is in summer. Now, let us take some of these blocks that are being made. I have tested personally a great many blocks, and I want to say to you that the average block a month old, yes, two, three months old, will barely give you 600 or 700 lbs. per square inch. On the other hand, I have seen blocks that have gone up from 1,500 to 2,000 lbs. in 28 days. I would venture to say that the average block as produced to-day would have a compressive strength possibly averaging 1,000 lbs. per square inch. Now, how does that compare with other building materials? A piece of granite may test from 18,000 to 24,000 or 26,000 lbs. per square inch. A piece of limestone may test from 8,000 to 16,000 lbs. per square inch. A brick, common ordinary red brick, may run 6,000 to 10,000 or 12,000 lbs. per square inch, and when you come to cinder concrete and materials of that kind, you get a lower compressive strength.

In order to show the possibilities in concrete I want to tell you of a little experience that they had at the Watertown Arsenal, in which concrete was allowed to set under what is known as cubical compression; that is, concrete was put into a cylinder, an old mortar (gun) provided with a plunger which just fitted that mortar—The concrete was put in the mortar, placed in a testing machine, and the machine's plunger pushed down, and maintained under a pressure of 100,000 lbs. per square inch, and the hardened concrete gave a strength of 19,000 lbs. pressure. It is not necessary for me to tell you that it is impossible to make blocks under such conditions, but I merely want to state that as an instance to illustrate a point which I am going to make. The hardening that occurs in your block is produced by crystalization. It is a law of chemistry, that the more rapidly the crystals

form, the coarser are the crystals; the more slowly the material crystalizes the finer is the crystal. Now, what is the effect of that in the hardening of the block? It simply means that the material sets very rapidly, which is a thing you all desire; but you get very coarse crystalization, which is not as dense, and therefore not as strong. But if the material sets very slowly, forming fine crystals, it is close in texture, is dense, and therefore has greater strength. The various building departments are preparing regulations. The building departments have a right to demand a certain strength and it is purely a matter of business as to what length of time you must cure your materials and under what condition you must harden them, so that you will produce an article that will meet all the requirements. It is not unreasonable for the building department to demand that this material should have the strength that other building materials have, because on the strength of the structure in which it goes depends the lives of people. It surely is quite evident that the wall in which it goes must carry a certain load; but what should be stated as the number of square inches of material that bears the load, so that we may know the compressive resistance of material in that wall? Allowance should be made for air space, and that is rarely given in the test. In the ordinary block which is 10x32, there would be a surface of 320 inches, and the load it stood would be the quotient that is obtained by dividing the 320 inches into the load carried. Now, if the block had 50 per cent of air space, there would be actually 160 square inches which carried that load. You should divide that product, 160 into the load, which gives you a correct compressive strength.

I do not think it makes any material difference as to the force that you use in molding cement. In using concrete the mixture must have enough water to allow for a proper hydration of the material; otherwise your block won't set. The more water you use the denser your mass. The closer together you can bring the materials that compose that mixture, the less porous is going to be your mass, if however, your mass is not compact you are going to have a porous product, which will permit water to pass through. I have seen blocks 10 inches thick, in a driving rain in which the water has come through and soaked the paper off the walls. I know you have all had experiences like that. I do not

care what the commercial feature is; if you will continue to make such blocks, you are going out of business, and it is going to be a business which nobody will take any interest in. If you can not make any more than ten blocks a day make them right, you had better make the ten and stay in business. There is no way that I know of, of forcing any water-proofing compound into the pores deep enough, that will make a permanent water-proof surface for any length of time. If the block is very porous it will draw water from the soil. Your wall on the outside may be perfectly dry then, and no water will appear there at all; but it will go up on the inside. To illustrate this point I would call your attention to the Cement Pavilion, World's Fair Grounds, St. Louis. Many of you perhaps saw the building which I refer to, which had walls 4 inches thick. The heaviest rain that fell on that structure never produced any moisture on the inside, and there was nothing used in that concrete except 4 parts of a very poor limestone which was all they could get at that time, two parts of a river sand, and one part cement. The concrete was very wet and was dumped down into the mould without any special tamping, and the result was a wall 4 inches thick through which the water did not go in a driving rain; and yet you will see walls that are 10 inches thick in which the water will go through like a sieve.

Mr. Watson: Could you tell how much limestone was used?

President Humphrey: 1, 2 to 4 generally, also 1, 3 to 6.

Mr. Pierson: Would not the brushing process have the tendency of filling?

President Humphrey: When the surface was brushed the hose was applied at the same time so that the particles which had been loosened were readily brushed away. The general impression is that the surface of blocks should be flooded with cement so as to plug up all holes. Here is the reverse condition.

Mr. John Driscoll: Was that concrete brushed immediately after being made?

President Humphrey: Almost immediately after the form was taken off. It was done for the purpose of removing the excess of cement and sand, and it was necessary to scrub the surface within 24 hours, when the concrete was still green. The inside was lightly covered with neat cement so as to fill up the

unevenness due to parts sticking to the form, and was covered with a light tint of common water paint to give it a better appearance.

Mr. Watson: Had that water paint something to do with the non-appearance of moisture on the inside of the wall? What did it consist of?

President Humphrey: No, it was just lime and water.

Now let us look at the concrete block situation. The early engineers who first used concrete believed that in order to produce good results the concrete must be very dry, and they tamped it by every means they knew until the water just flushed; but after awhile some of the engineers gave the matter more thought and they added more water to the concrete, making a tighter body. In the experimental station at St. Louis we use in reinforced concrete an exceedingly wet mixture without tamping or pounding. With a wet concrete there will always be trouble in removing the mold. This is the great difficulty in the use of wet mixtures, but it is a problem that must be solved and the block maanufacturer must solve it if his product is to become more nearly perfect.

Mr. Watson: Can you get too much water in that cement concrete in your opinion?

President Humphrey: Within reasonable limits I do not think that you can get too much water in the concrete. You can have as high as 27 per cent, but of course, the richer the material is in water, the more easily it is affected by heat, so that it becomes objectionable to have too much water for crystalization. Of course, you must be careful not to go to extremes for if you use too much water you have a syrup, it will be too thin. But if you will use 10 per cent water and have a dry mix, the addition of may be 1 per cent of water more will give you a little better mixture. I think the extreme ranges between these wet and dry mixtures are just as elastic as some of the terms you have had here. I think the average condition of the mind of the man who has attended the convention and does not know anything about the cement business, must be chaotic, for where differences of opinion have arisen proof has been brought to substantiate both, and statements have been proven and absolutely misproven. But you must not be particularly influenced by that. You, perhaps, came to this convention with the idea of securing

some solution to a problem that had been confronting you, and during the course of the convention you hear just that experience, you learn just the remedy that you have been looking for, and you can go home and feel that your coming to the convention and the necessary expense it incurred, has been well repaid. But if one has had no previous knowledge of the block business and should remain in attendance from now until the end of time, I do not believe he would know any more at its adjournment than he knows now.

Now, just one word in regard to the condensation that takes place on concrete. That is something that will occur on any material, and the only way you can guard against it is to so protect the surface on the inside that it cannot possibly receive this precipitation. Now, at the World's Fair there was a building (with a roof 2½ inches and walls 4 inches thick) in which we kept our specimens. In the night the air was charged with water, and this water would gather on the walls in the form of frost. Just as soon as the sun rose in the morning, we would have the water dripping from the ceiling, and the impression was created that the roof leaked. It was simply that the material was not a sufficiently good conductor of heat, and it permitted the water to precipitate on the wall. By putting an insulation on the roof, the entire trouble was remedied, and it has not occurred since. You have without doubt all noticed the condensation of moisture on the inner side of a window. That is not moisture which has penetrated the glass for it may collect there with the sun shining on the window. It collects for the following reason: At a given temperature air can hold a certain definite amount of moisture and any change of temperature will alter the moisture conditions. If this amount of moisture is present and the temperature rises the air could hold more moisture and evaporation would take place if water were present, but if the thermometer falls the air is supersaturated, the moisture condenses and is deposited on any surfaces present. Therefore if your window or, it may be a wall, is cold, as it will be in winter, the air, due to the drop in temperature in the immediate neighborhood of the wall is over charged with moisture and causes it to be deposited. If, however, the moisture contained in the air of the room is not sufficient to saturate it at the temperature existing near the wall no moisture will be deposited.

Mr. C. W. Stevens: I would like to ask you one question. Have you had experience in water-proofing between the grade and the blocks? In some localities I understand that you are compelled to by law, and when I was traveling in England, I was informed that the law there required the placing of water-proofing compounds for installation material under the walls of every building; even under a large country road wall. One gentleman informed me that he had a contract for seven miles of water-proofing under a building for a reform school, and told me that was the universal law throughout the kingdom.

President Humphrey: I think compelling insulation is a very good regulation, for there is nothing more unhealthful in a building than moisture which gathers germs and is a source of disease.

Mr. Watson: Having brought the discussion to that point, let me say that some of the architects have specified in cut stone specifications that the stone should be painted with a waterproofing compound, but we have not found this satisfactory. It has destroyed the bond between the stone and the wall, and it does not seem to make any difference because the moisture gets through the joints; and you have a much worse looking job. The waterproofing compound is to be put upon the back of the stone before it is in the wall.

President Humphrey: What do you back that up with?

Mr. Watson: Brick or concrete, or what is specified.

President Humphrey: And you say it destroys the compound?

Mr. Watson: Yes; the moisture comes through the joints and the waterproofing is of no effect. We have since used La Farce Cement which has been found to be a good material, when mixed 1 to 3.

Mr. John Driscoll: There was a paper read at the Indianapolis Convention last year, by an engineer who had had experience in covering tunnels, bridges, railroads, etc., with water-proofing concrete, or other masonry. He said the best method was to give it a coat of asphalt or pitch tar, and I have tried some of that for coating a wall on the outside, applying it after the wall was laid, so as to cover the joints and the blocks, and it was the most satisfactory way that I have ever seen for that purpose.

President Humphrey: That is quite true. The only great objection to these asphalt preparations is that they lose their waterproofing qualities with time, that is, they are acted on by water, which causes them to rot. If the material is properly made, as many of these materials are, then they will stand almost indefinitely for a long period of time.

Mr. H. N. Jones: I would like to ask Mr. Watson whether that waterproofing compound was put on as waterproofing, or was it the old custom of backing up limestone to prevent the action of the cement back in discoloring it.

Mr. Watson: It was intended for both. Of course, we know that limestone set in Portland cement would stain. The reason why it was adopted was as an experiment to avoid that stain. It was put in between the stone and wall to prevent the moisture from coming through the stone. It was, therefore, put on to accomplish both purposes.

I want to ask another question about moisture. There was a discussion about drowning the cement in too much water. Have you had any experience in mixing very wet?

President Humphrey: That is a good point. A point probably worthy of comment. The materials should be mixed so that the particles are brought in contact with each other, and the more that material is mixed the closer is going to be the relation between one particle and another. When you take sand and stone, add cement to them and mix them up dry you enclose a lot of air in that mixture. Now you add water to it and mix it; that air is still enclosed in there, and when you place your concrete you have numerous air holes which make the block porous. Now, the more you turn that material over the more air you get out; and the more air you get out the denser is going to be your result. The water that is in there is going to enter into the combination, but the air will prevent these particles from coming into contact with each other. The only draw-back to wet mixture, is the fact that they may get into a pasty condition which is undesirable. I have seen examples of the different methods of mixing in laboratory work when our Committee on Uniform Tests of Cement of the American Society of Civil Engineers was considering the question of the proper method of mixing a mortar. To make a proper test, some would say: "You ought to mix that with a trowel" some said, "You have to mix

it with a hoe in a little trough," or, "You should mix it with a spoon," and knead and work it with your hands. You would be surprised as to the amount of water used by different experimenters. They differed all the way from 16 to 27 per cent. Some men would work the material by different methods for half a minute; some for three minutes. If the cement was quick-setting, it began to set before they had it mixed. It was found that when all the material was worked and turned over, that a much better mix and a greater percentage of strength was obtained than if it had been worked with a trowel or with a hoe. We find by taking a mixing machine and tumbling it around that we can obtain the best results. Our methods in the laboratory on a small scale are exactly the same as you are using on a large scale, and the principle is just the same. During these tests people would use 16 per cent of water, take a trowel and rub it back and forth, and another one took a mallet and hammered the mortar continually. On the other hand, another man merely mixed it between his finger and his thumb, and with his hand would push the mortar up and down and thoroughly mix the particles; and that experimenter obtained as strong results as the one who hammered it with a mallet. It is not the amount of pressure that you apply, but it is the thorough mixing and the intermixing of the various ingredients which counts.

Mr. G. J. Hamill: In arriving at the percentages you mentioned, 16 and 27, what has been your method?

President Humphrey: In a laboratory, when we speak of a certain percentage of water, we mean percentage by weight. That is, if we had a thousand ounces of cement, we would use a certain percentage of that as the weight of water required.

Mr. Watson: What is the effect of depositing concrete in water immediately after mixing, instead of waiting a few hours and exposing it to the air before depositing?

President Humphrey. That is a very simple question to answer. If you take the concrete and mix it up, the water will go through and take away the strength, but if you take the concrete, provided it is just simply wet, and place it under water, it will set just as well, probably better, than if it was out in the air.

Mr. Watson: What is your experience in putting a cast in a steam jacket to accelerate the set?

President Humphrey: Steam acts as a hardener, since it

raises the temperature in the room through which it passes.

Mr. Pierson: I would like to ask, inasmuch as none of us know how to make a wet block, and it does not seem feasible to stick to the dry process, how would it do to steam the aggregates a little while, so that they are thoroughly moistened, before they are put to use, and then mixing with the cement? Do you think it would assist any?

President Humphrey: I think, Mr. Pierson, that in the final solution all air must be removed from the block. In order to accomplish this, you will have to dry your sand thoroughly, see that your cement is dry, and then mix them thoroughly in their dry condition, thus working out a great deal of the air. The reason why there are so many failures in the dry process is because you do not put enough work in it. I have heard people get up here and say that they turned it once, twice or three times. That is not enough. Do not throw it up in the air, for by doing that air will get in your mixture. Get the sand, stone and cement all thoroughly mixed together, and you can get very good results under ordinary conditions.

Mr. John Driscoll: I have been in the manufacture of blocks by the dry process for quite a number of years, and I am put in the same position as the gentleman that last spoke. We would all like to get more water, provided we can hold the features of our product, for with the ordinary methods, when we strip our blocks, we pull off a face and it sticks to the molds. Lately I have tried hydrated lime for waterproofing, and it is most satisfactory; and I have tried all the recommended waterproofing of different kinds. I can take a block made by dry process in which I have put hydrated lime, pour water on that block, and it will just drink it up. I do not know whether the water is absorbed by the sand, but I know that all of the experiments I have made along these lines the use of hydrated lime has proven most satisfactory.

Mr. S. W. Hoffmann: I would like to say for the benefit of this gentleman, that we have made blocks with a very light facing, using a crushed white sandstone with a rich mixture of 1 to 2, and then used 1, 2 and 4 mixture of such a consistency that the hollows would hold water. When you want to remove them from the mold they would stick to the box. If you had a core in it that would draw out considerable water, but give it more on the bottom. The wet mixture, I find, will stand up better

in that way, and I obtained very good results, better than I ever saw with a machine-made block.

President Humphrey: I would like to ask Mr. Driscoll how many times he mixes his material dry?

Mr. John Driscoll: I was in the cement sewer business for a great many years before I went into the block business, and in the sewer businss our method is the Scotch and German method. We mix the cement, sand and stone together with a hoe and turn the mixture not less than eight or nine times dry, and the same number of times after wetting, so that on an average, we turn about fifteen to twenty times with a hoe. I find that the mixture will take the water up very rapidly.

Mr. E. Kenney: I find from a long experience with mortar that it will absorb and accomplish a good deal more at the latter part of the stage than at any other time.

Mr. Stevens: I cannot agree with the gentleman who made the statement that the wet process will absorb more than the dry. I do not find it so; in fact, on a test, a piece of our stone, weighing about four pounds, was taken, and it absorbed so little over night that they could not detect it on the scales. In another case, however, an older stone, weighing about seven pounds, when immersed in water absorbed eleven pounds.

Mr. E. F. Arn: I made a building, using the dry process, and used plenty of gravel. Then I got the mixture so wet that you could hardly set it down, and the water ran all over the mold, as though we were pouring the concrete. I plastered directly back of that and had no complaint whatever.

Mr. Stevens: We never recommend the plastering of a wall, no matter how light the absorption. We put up several buildings in our town, and in one instance the moisture did not exceed 7 per cent, but in one of the rooms the moisture showed through, and we advised the owner at the time not to plaster the wall. He did so, however, and the result was that the moisture came through and spoiled all the plastering.

Mr. L. E. Porter: I should like to know what the proportion of mortar should be in setting these stones, and what the best method of setting is.

President Humphrey: I would consider a mixture of 1 to 3, depending upon the conditions, very satisfactory. If you use a little lime, it can be handled better by the mason. It has been the

custom for many years to add a hydrate of lime, but we do not use it here. You all know, without my telling you, that a Portland cement mixture of 1 to 3, is very short, and if a man has to work over that all day, his wrist is pretty nearly broken by the time he gets through.

Mr. L. E. Porter: When I told the contractor in one instance in my town that there should be lime in the mortar, he said that the addition of lime would kill the cement.

President Humphrey: I am convinced that the contractor was mistaken. I do not believe that an addition of 5 per cent of lime would at all hurt the material.

Mr. L. E. Porter: I put up a house and used one part of cement in the mortar and two parts of sand and one-half part of lime product. That was my mortar; is that all right?

President Humphrey: I think that is pretty rich. Although you had twice as much cement as lime in your mixture, your lime simply diluted it. In experiments that we have made we have used lime mortar bricks which broke at fifty pounds per square inch. Now, out of the cement you can get 400 pounds per square inch; therefore the cement is eight times as strong as the lime mortar. If you take a material that is one-eighth as strong as the material you add to it, you are just making it that much weaker. The hour for adjournment has now arrived, and in bringing this convention to a close, I want to congratulate you on its success. The amount of valuable information that has been exchanged by those who came here—men who were actually doing the concrete work—is one of the best and most gratifying evidences of this success.

In bringing this convention to a close, I do so with considerable regret, and with the sincere wish and hope that we may have many more of its kind.

SUMMARY OF PROCEEDINGS.

FIRST SESSION, TUESDAY, JANUARY 9, 3:00 P. M.

First Session: Tuesday, January 9, 3:00 P. M.

President Richard L. Humphrey in the chair.

The proceedings of the First Annual Meeting were approved as printed.

The following papers were read and discussed:

"Concrete Aggregates;" Sanford E. Thompson.

"The Use of Salt in Sidewalk Construction," George L. Stanley.

The meeting adjourned till 8:00 P. M.

SECOND SESSION, TUESDAY, JANUARY 9, 8:00 P. M.

President Richard L. Humphrey in the Chair.

President Humphrey read his annual address.

A paper entitled, "Some Notes on Reinforced Concrete," was presented by A. L. Johnson.

The meeting then adjourned until Wednesday at 10:00 A. M.

THIRD SESSION, WEDNESDAY, JANUARY 10, 10 A. M.

President Richard L. Humphrey in the Chair.

The following papers were read and discussed:

"Cement and Building Construction," C. A. P. Turner.

"What the Cement Users Owe to the Public," R. W. Lesley.

Meetings of the following sections to elect sectional vice-presidents, were held at the close of the session:

Section on Concrete, Blocks and Cement Products.

Section on Streets, Sidewalks and Floors.

Section on Reinforced Concrete.

Section on Art and Architecture.

Section on the Testing of Cement and Cement Products.

Section on Machinery for Cement Users.

Section on Fireproofing and Insurance.

Section on Laws and Ordinances.

The meeting then adjourned until 3:00 P.M.

FOURTH SESSION, WEDNESDAY, JAN. 10, 3:00 P. M.

President Richard L. Humphrey in the Chair.

The report of the executive committee was adopted as read, and the committee instructed to incorporate the association.

The President appointed the following nominating committee: R. W. Lesley, M. S. Daniels, T. L. Condron, J. P. Sherer and A. L. Johnson.

The report of the Section on Testing Cements and Cement Products was adopted as read.

A topical discussion on the manufacture of concrete blocks was then started.

It was resolved that the following resolution be sent to the speaker of the House of Representatives and each member of the convention was requested to send a copy with his endorsement to the member of Congress representing his district:

"To the Honorable, the Speaker of the House of Representatives, Washington, D. C.

Resolved, That we, the National Association of Cement Users in convention assembled at Milwaukee, Wisconsin, deem the investigations of cements, mortars, and other structural materials, now being conducted by the United States Geological Survey, of such far reaching importance to the people of this country, that we respectfully ask the Congress of the United States to make a larger provision for the continuance of this important work on a more extensive scale during the next year."

The Committee on nominations made the following recommendations:

For President—Richard L. Humphrey, Philadelphia.

First-Vice-President—Merrill Watson, New York.

Second Vice-President—J. H. Fellows, Scranton.

Third Vice-President—O. U. Miracle, Minneapolis.:

Fourth Vice-President—A. Monsted, Milwaukee.

The Secretary was directed to cast the ballot for these officers.

The following Sections reported the election of Vice-Presidents:

Section on the Testing of Cement and Cement Products—E. S. Larned.

Section on Concrete Blocks and Cement Products—M. F. Daniels.

It was moved, seconded and carried that the men named and those that will be subsequently named by the various sections before the adjournment of the convention, be elected by the Convention, and that the Secretary be instructed to cast a ballot for these officers:

The meeting then adjourned till 8:00 P. M.

FIFTH SESSION, WEDNESDAY JANUARY 10, 8:00 P. M.

President Richard L. Humphrey in the Chair.

The following paper was read and discussed:

Cement Block Architecture," Louis H. Gibson.

The report of the Committee on Art and Architecture was adopted as read.

The following papers were read and discussed.

"The Use of Cement and Concrete for Farm Purposes," S. M. Woodward.

The meeting then adjourned till Thursday at 9:00 A. M.

SIXTH SESSION, THURSDAY, JANUARY 11, 9:00 A. M.

President Richard L. Humphrey in the Chair.

The following papers were read and discussed:

"The Manufacture and Use of Concrete Piles," Henry Longcope.

"Machinery for Cement Users," W. W. Benson.

"Waterproofing," J. L. Mothershead, Jr.

"Legislation on Concrete Building Blocks," Will J. Scoutt.

The meeting then adjourned till 2:30 P. M.

SEVENTH SESSION, THURSDAY, JAN. 11, 2:30 P. M.

President Richard L. Humphrey in the Chair.

The following papers were read and discussed:

"The Manufacture of Hollow Concrete Blocks," S. B. Newberry.

"Causes of Failure in the Concrete Block Business," O. U. Miracle.

"The Selection of Portland Cement to be used in Manufacture of Concrete Blocks," Richard K. Meade.

"Observations on the Testing and Use of Portland and Natural Cements," E. S. Larned.

The section on Art and Architecture reported the following elections:

Vice-President—Charles D. Watson.

Secretary—H. J. Jaxon.

The meeting then aljourned till Friday at 9:00 A. M.

EIGHTH SESSION, FRIDAY, JANUARY 12, 9:00 A. M.

President Richard L. Humphrey in the Chair.

The meeting was opened by a topical discussion on side-walk construction.

By letter or through representatives the National Association of Cement Users was invited to hold its annual meeting in 1907, in the following cities:

Columbus, Norfolk, Va., Chicago, Cincinnati, Denver and Jackson, Mich. After considerable debate it was resolved that each member indicate by ballot the city of his first, second and third choice.

A vote of thanks was extended to the City of Milwaukee for its hospitality.

The meeting then adjourned till 2:30 P. M.

NINTH SESSION, FRIDAY, JANUARY 12, 2:30 P. M.

President Richard L. Humphrey in the chair.

The following sections reported the election of Vice-Presidents:

Section on Streets, Sidewalks and Floors,—Geo. L. Stanley.

Section on Reinforced Concrete.—T. L. Condron.

The ballot indicating the choise of the members voting for the city in which the next convention is to be held resulted as follows:

The city of first choice:

Chicago	60
Columbus	27
Jackson	15
Kansas City	4
Toledo	1

The city of second choice:

Columbus	25

Jackson..... 25
Chicago..... 22
Kansas City..... 13
Norfolk..... 4
Cincinnati..... 3
Cleveland, Buffalo, Toledo and Louisville, each (one)..... 1

The city of third choice:

Columbus..... 27
Jackson..... 21
Chicago..... 21
Kansas City..... 14
Detroit..... 3
Norfolk..... 3
Cincinnati and Minneapolis, each..... 2
Toledo and Port Huron, each..... 1

The report of the Committee on Laws and Ordinances, H. C. Henley, Chairman, reported progress.

The following papers were read and discussed:

"Legislation Concerning the Use of Cement in New York City," R. P. Miller.

"Manufactured Stone," J. C. McClenahan.

The Committee on Fireproofing and Insurance presented their report.

The convention then adjourned sine die.

REGISTRY OF THOSE MEMBERS IN ATTENDANCE.

Richard L. Humphrey, 1001 Harrison Bldg., Philadelphia, Pa.
Merrill Watson, 256 Broadway, New York.
A. Monsted, Pabst Bldg., Milwaukee, Wis.
Charles Carroll Brown, Secretary.
Commercial Club Bldg., Indianapolis, Ind.
A. S. J. Gammon, Citizens' Bank, Norfolk, Va
Charles D. Watson, Roman Stone Co., Toronto, Can.
The Durolithic Co., North Tonowanda, N. Y.
Geo. F. Fisher.
Ricketson,, Mineral Point Works,
Broadway, Milwaukee, Wis.
W m. Pfleger.
J. Frey.
Milwaukee Concrete & Supply Co.,
D. N. Harper, 54 Home Bank Bldg., Detroit, Mich.
Matthews Bldg., Milwaukee, Wis.
S. D. Austin.
National Building Block Machinery Co., Milwaukee, Wis.
H. T. Behrle, 629 Mock Ave., Detroit, Mich.
Miracle Pressed Stone Co., Minneapolis, Minn.
O. W. Miracle.
Passaic Co., Miracle Pressed Stone Co., Railroad Ave., Paterson, N. J.
John H. Westing.
Two Miracles Concrete Co., Minneapolis, Minn.
R . O. Miracle.
Sandusky Portland Cement Co., Sandusky, O.
Clen M. Porter, Chicago.
Concrete Building Block Co., Badger Ave., Newark, N. J.
J. H. Twitchell, Supt.
Reading Brick Machinery Co., 405 Baer Bldg., Reading, Pa.
D. P. Sanders.
Berthelet Construction Co, Milwaukee, Wis.

Geo. S. Bartlett.
Sandusky Portland Cement Co., Sandusky, O.
R. R. Fish, Ft. Wayne, Ind.
Contractors' Supply & Equipment Co., Van Buren and Dearborn Sts., Chicago, Ill.
F. B. Wright.
Jno. Trever.
The T L. Smith Co., 604 Merrill Bldg., Milwaukee, Wis.
E. W. Meyer.
T. L. Smith.
W. J. Buckley.
National Building Block Machinery Co., 211 Grand Ave., Milwaukee, Wis.
J. P. Sherer.
Berthelet Construction Co., 7 Plankinton Bldg., Milwaukee, Wis.
J. R. Berthelet.
V. E. Berthelet.
Wm. T. Berthelet.
Walter Burke.
Edison Portland Cement Co., Pittsburg, Pa.
G. B. Nutt.
Perfection Block Mach. Co., 501 Kasota Blk., Minneapolis, Minn
M. K. Sawyer.
Queen City Brick Machine Co., 2 Merc. Co. Blk., Traverse City, Mich.
W. J. Hobbs.
Hartwick Machinery Co., Jackson, Mich.
J. W. Hartwick.
Geo. Schuffler
Helm Brick Machine Co., Traverse City, Mich.
E. S. Williams.
Art Building Block Machinery Co., 119 Liberty St., Jaackson, Mich.
A. M. Haight.
Indestructible Post Co., Chicago, Ill.
Easy Block Handlers, Appleton, Wis.
John Driscoll.
M. K. Gochnaur.
T. M. Le Hew & Son, Warsaw, Ind.

T. M. Le Hew.
John N. Le Hew.
Castalia Portland Cement Co., 209 Ninth St., Pittsburg, Pa.
Charles L. Johnson.
Eastern Concrete Machinery Supply Co., Akron, N. Y.
J. R. Thomas.
Barker & Nighswander, Jefferson Ave. and Water St., Toledo, Ohio.
Dr. W. S. Barker.
The Standard Machine Co., Kent, O.
F. A. Kershaw.
Barker & Nighswander, Toledo, O.
C. F. Nighswander.
W. W. Barker.
The Western Builder, 308 Montgomery Bldg, Milwaukee, Wis.
Ivan C. MacDonald.
D. S. Roberts, Davidson Hotel, Milwaukee, Wis.
Adolph Adams, Kendallville, Ind.
C. W. Boynton, 1057 Rookery, Chicago, Ill.
Cement Machinery Mfg. Co., Burlington, Ia.
W. Sanderson.
Illinois Steel Co., Cement Dept.., 1063 Rookkery, Chicago, Ill.
B. H. Rader.
South Bend Machinery Mfg. Co., South Bend, Ind.
A. P. Starr.
E. Snell.
H. H. Hutson.
Geo. Braun.
Long Island Concrete Building Block Co., Bayside, N. Y.
Geo. J. Hamill.
Wisconsin Hollow Concrete Wall Co., 314 Broadway, Milwaukee, Wis.
Walter B. Potter.
W. H. Carson.
National Builder, 358 Dearborn St., Chicago, Ill.
E. B. Hoy.
Fairbanks, Morse & Co., 134 Sycamore St., Milwaukee, Wis.
C. L. Dane.
Rubendall Bros., Princeton, Ill.

Edward Rubendall.
Neck Bros., Montello, Wis.
B. Neck.
Lehigh Portland Cement Co., Allentown, Pa.
C. F. O'Neill.
C. A. Matcham.
Milwaukee Concrete & Supply Co., Milwaukee, Wis.
J. F. Lockley, Agt. for Newaygo Portland Cement Co., Grand Rapids, Mich.
The Jaeger Machine Co., 313 W. Broad St., Columbus, O.
G. Jaeger.
Western Portland Cement Co., Yankton, S. D.
G. S. Bartlett, Milwaukee, Wis.
C. B. McKay, Milwaukee, Wis.
W. W. Bailey, Chadwick, Ill.
J. W. Spinka, Chadwick, Ill.
Harmon S. Palmer.
Chas. W. Kenney, 2353 W .Jackson St., Chicago, Ill.
J. D. Wood.
H. H. Swan.
Century Cement Machine Co., 181 W. Main St., Rochester, N. Y.
A. T. Bradley.
Ely Roberts.
Lewis Kuster.
Geo. Abbott.
C. R. Lehrack.
O. D. Tiffany.
Robert Siebert.
W. O. Williams.
W. H. Gilbert, Olney, Ill.
Herman Loeffel, Cape Girardeau, Mo.
Illinois Gravel Co., Princeton, Ill.
L. W. Scott.
C. W. Scott.
Stevens Cast Stone Co., 147th St. Harvey, Chicago, Ill.
C. W. Stevens.
G. W. Tainter, Jr.
Municipal Engr. & Constr. Co., 609 Railway Exchange, Chicago, Ill.

Iver R. Johnson.
The Standard Sand & Machine Co., 1507 St. Clair St., Cleveland, Ohio.
A. L. Boughton.
J. W. Boughton.
J. E. Wilson, Jr., Logan, Utah.
St. Louis Expanded Metal Fireproofing Co., St. Louis, Mo.
T. L. Candron, Chicago, Ill.
A. L Johnson, St. Louis, Mo.
F. R. Goodrich, Traverse City, Mich.
Atlantic Concrete Mfg. & Const. Co., Atlanta, Ga.
S. C. Arkens.
Nice Rasor Co., Barberton, Ohio.
W. H. Nice.
O. O. Rasor.
Atlanta Concrete Mfg. & Const. Co.
J. N. Brown, Pres.
The Art Stone Supply Co.
J. L. Nutter.
Cement Stone & Supply Co., Wichita, Kan.
I. F. West.
Little Rock Artificial Stone Co., Little Rock, Ark.
D. G. Taylor.
Joseph Babrezky, Guardian Trust Bldg., Kansas City, Mo.
The Pettyjohn Co., 603 N. 6th St., Terre Haute, Ind.
W. P. Pettyjohn.
L. Pettyjohn.
W. A. Bruce, 3161 Northwestern Ave., Indianapolis, Ind.
Concrete Construction Co., John Edelman, Mgr., Muskegon, Mich.
Honore J. Jaxon, 681 W. Lake St., Chicago, Ill.
Consolidated Litholite Co., Saratoga Springs, N. Y.
David B. Ledlie.
H. E. Haskins, Lake Geneva, Wis.
R. E. Cunningham, Cunningham Bros., Brooks, Ind.
W. & H. Beirer, 813 E. 6th St., Alton, Ill.
Henry Beirer.
W. C. Beirer, Pres.

E. C. Mack.
Illinois Steel Co., Rookery, Cement Dept., Chicago, Ill.
Henry S. Backus, Chicago, Ill.
S. W. Hoffman, Zanesville, Ohio.
Adam Saal, Peoria, Ill.
The Dykema Co., 939 Mich. Trust Bldg., Grand Rapids, Mich.
F. L. Dykema.
Northewestern Expanded Metal Co., 790 Old Colony Bldg., Chicago, Illinois.
Geo. Roden.
E. E. Benner, Sargent, Neb.
C. L. Harris & Son, Sargent, Neb.
Chas. W. Diener, Cement Products Co., Burlington, Wis.
The Phillips Cement Stone Co., 705 Oakwood Ave., Columbus, Ohio.
Geo. B. Moogk, Waterloo, Ont.
J. B. Fraham Fuel & Const. Co., 304 Harrison St., Davenport, Ia.
J. B. Fraham.
B. C. Fraham.
Kelley Island Lime & Transport Co., Cleveland, O.
Geo. P. Schwab.
S. L. Dunlap, Park Ave., Indianapolis, Ind.
H. N. Jones, Houston, Tex.
A. C. Birnie, Ludlow, Mass.
C. Walker & Son, North Platte, Neb.
Ed. Walker.
James J. Farley, Farley & Co., Homer, Ill.
Meacham & Wright Co., 921 Chamber of Commerce Bldg., Chicago, Illinois.
Chas. G. Reid.
Schuetle Cement Const. Co., Manitowoc, Wis.
H. E. Murphy.
Geo. H. Lowe, Arlington, Mass.
The Schoeneman Cement Block Co., George, Iowa.
D. A. Schoeneman.
Schuelte Cement Construction Co., Manitowoc, Wis.
H. C. Schuelte.
W. C. Schlaeter Co., Manitowoc, Wis.
W. C. Schlaeter.

J. G. Johnson.
164. F. K. Mayne, Blue Springs, Neb.
Howard G. Goodwin, 281 W. Market St., Akron, Wis.
Oswall A. Dreman, Waukesha, Wis.
Sullivan Cement Works, Sullivan, Ind.
Alfred H. Mankedick.
Chas. Mankedick.
B. K. Kramer, 225 Main St., LaFayette, Ind.
E. Kenney, 423 W. Lucas St., Creston, Iowa.
W. H. Lucas, 187 Buckingham St., Newark, Ohio.
Buser Concrete Construction Co., Mt. Morris, Ill.
N. E. Buser.
R. E. Buser.
Geo. L. Stanley, Ashtabula, Ohio.
Harry C. Sense, LaFayette, Ind.
West Bend Concrete Works, West Bend, Wis.
The Schatzinger Con. Realty Co., Cleveland, Ohio.
B. Schatzinger.
B. J. Schatzinger.
South Side Cement Co., Milwaukee, Wis.
Toch Bros., 320 5th Ave., New York.
F. H. Upton.
T. W. Saveland.
W. H. Ward & Son, Harvard, Ill.
J. R. Harrington, Edinburg, Ill.
Hot Springs Concrete Co., Hot Springs, Ark.
W. S. Sorrels, Pres.
C. E. Marks, Manager.
York Hydraulic Stone Co., York, Neb.
L. E. Porter.
Wm. Bell. 509 Hill Ave., Elgin, Ill.
F. F. Arn, Barnett St., Kansas City, Kan.
John A. Rodgers, 302 McCall St., Waukesha, Wis.
Harry Eickemeyer, 417 S. Madison St., Bay City, Mich.
Pennsylvania Coal & Supply Co., Milwaukee, Wis.
C. C. Sprague.
Otto Gelhaar.
South Side Cement Co., 257 Reed St., Milwaukee.
H. R. Hansen.

Mandt-Powell Concrete Machinery Co., Stoughton, Wis.
O. G. Mandt.
M. G. Mandt.
Fulton County Supply Co., 105 1-2 Pryor St. Atlanta, Ga.
J. L. Clark, Mgr.
Wingit Concrete Machine Co., 482 N. High St., Columbus, Ohio.
J. F. Angell.
H. W. Bedell, Bloomfield, Ont.
Arthur N. Pierson, 1 Park Row, New York.
New Jersey Cement Stone Co., 89 Dodd St., East Orange, N. J.
J. W. Pierson.
Sponholz Co., 409 Uihlein Bldg., Milwaukee, Wis.
E. A. Sponholz.
Kus Kahn.
J. W. Clark, 527 S. Elm St., Centralia, Ill.
J. M. Blakely, 541 Union St., Centralia, Ill.
B. F. Hayes & Co., Liberty, Mo.
Denver Cement Tank & Silo Co., Cassopolis, Mich.
O. A. Dever.
E. K. Black.
Ft. Wayne Cement Stone Co., 2027 Nelson St., Ft. Wayne, Ind.
L. Chas. Jacquel.
Stocker Gravel & Art, Stone Co., Highland, Ill.
Fred Stocker.
H. A. Zobrist.
St. Louis Granitoid Curb Co., 1909 Lafayette Ave., St. Louis, Mo.
Robert Schulz.
Chicago Pneumatic Tool Co., Chicago, Ill.
Chas. V. Walker.
Hotchkiss Concrete Stone Co., 315 Dearborn St., Chicago, Ill.
Wm. S. Hotchkiss.
John Buehler, Perley, Wis.
Cummings Structural Concrete Co., 4 Smithfield St., Pittsburg, Pa.
Robert A. Cummings.
Cement & Engineering News, 224 La Salle St., Chicago, Ill.
Wm. Seafert.
Graham Construction Co., 406 Free Press Bldg., Milwaukee, Wis.
Jas. Graham.

Wm. Lough, Ascola, Ill.
Graham Construction Co, Milwaukee, Wis.
W. J. Graham.
The Kakiat Co., Suffern, N. Y.
M. S. Daniels.
St. Louis Hollow Concrete Block Co., 7600 N Broadway.
St. Louis, Mo.
Geo. Guthrie.
South Side Roofing & Cement Co., 235 Reed St., Milwaukee, Wis.
A. Toppins.
Frank Rumpf, Two Rivers, Wis.
Kennedy & Berry, Detroit, Mich.
Horace G. Smith.
The Standard Stone Co., 1 Madison Ave., New York.
J. C. McClanahan.
W. W. Benson.
L. J. Thompson.
Evanston Hydraulic Stone Co., 1580 Sheridan Ave., Evanston, Ill.
F. H. Gill.
N. Underwood.
Evanston Hydraulic Stone Co., Evanston, Ill.
J. P. English.
James Wigginton, Jr.
Tom J. Foley.
H. M. Lavers.
The Cleveland Car Co., West Park, Ohio.
W. H. Caskey, Cleveland, Ohio.
J. W. Stuart, Paris, Ill.
R. B. Sears, 13 Park Row, New York.
A. Monsted & Co., Milwaukee, Wis.
H. C. Fuldner.
Cement Machinery Co., Jackson, Mich.
S. L. Wiltse.
Samuel Munnell, Canonsburg, Pa.
John McNary, Canonsburg, Pa.
Alton Roofing Artif. Stone & Supply Co., Alton, Ill.
H. Luer, Secy.
E. J. Ash, Mgr.
National Concrete Construction Co., Board of Trade

Bldg., Louisville, Ky.
Webster Gaglay.
Jas. B. Wilson, 324 Dearborn St., Chicago, Ill.
P. P. Welty, Columbus Grove, Ohio.
Parkersburg Artificial Stone Co., 410 George St., Parkersburg, W. Va.
S. H. Lowther.
Evanston Hydraulic Stone Co., Evanston, Ill.
J. Robert Gill, 2798 N. 47th Ave., Chicago, Ill.
Alpha Portland Cement Co., Evanston, Pa.
Henry Longcope, Philadelphia, Pa.
City Construction Co., Milwaukee, Wis.
Jas. O'Connor.
John S. O'Neill.
Lamb & Rutledge, Newark, Ohio.
John P. Lamb.
Jos. W. Rutledge.
Marquette Cement Mfg. Co., Chicago, Ill.
John W. Dickinson.
F. M. Frost & Sons, Jerseyville, Ill.
Marquette Cement Mfg. Co., Chicago, Ill.
John A. Dunlap.
Wm. Dickinson.
Robert B. Dickinson.
Harry Woodhouse, Halcyon Place, Yonkers, N. Y.
R. H. Lathers, 524 Baker St., Detroit, Mich.
Ideal Concrete Machinery Co., South Bend, Ind.
F. A. Borst.
F. Schnurr.
S. L. Kelly.
G. B. Pulfer.
E. S. Hotchkiss, Chicago, Ill.
Ideal Concrete Machinery Co., South Bend, Ind.
F. J. Fitzsimmons.
Walton Granalithic Co., 2500 E. 18th St., Kansas City, Mo.
E. M. Walton.
I. L. Walton.
E. M. Walton.
Simpson Bros., Corporation, 166 Devonshire St., Boston, Mass.
N. P. Winchell, Asst. Treas.

J. B. Simpson, V.-Pres.
Northwestern Tile Co., Grand Ave., Milwaukee, Wis.
Mr. Cutter.
Mr. Dolman.
Mr. Sivyer.
Wm. Durnthy.
Bellevue Stone Co., Bellevue, Ohio.
T. E. Wyant, Bellevue, Ohio.
Chicago Portland Cement Co., Stock Exchange Bldg., Chicago, Ill.
D. D. Drummond.
The Besser Mfg. Co., Alpena, Mich.
J. H. Besser.
Wm. Hurley, 426 Marietta St., Buffalo, N. Y.
Capital City Concrete Con. Co., 214 S. 6th St., Springfield, Ill.
P. E. Tamtor.
L. E. Lawson.
C. A. P. Turner, 816 Phoenix St., Minneapolis, Minn.
Lillibridge & Anderson, St. Charles, Ill.
C. A. Anderson.
W. P. Lillibridge.
Charles Robinson, Wenona, Ill.
Con Gminer, Waupaca, Wis.
McLaughlen Mateer Co., Kankakee, Ill.
W. S. McLaughlen.
C. E. Mateer.
Joe Ubbink, Port Washington, Wis.
J. M. Rusk, Mulford, Ill.
J. A. Fried, Lincoln, Nebraska.
Jas. P. Hall, Foot Henderson St., Jersey City, N. J.
American Cement Co., 101 Milk St., Boston, Mass.
E. S. Larned.
Robt. W Lesley, Penna. Bldg., Philadelphia, Pa.
Lehigh Portland Cement Co.
T. E. Paulson, Indianapolis, Ind.
The Concrete Stone and Sand Co., 907 Poland Ave., Youngstown, Ohio.
A. A. Paul.
T. Beham.

W. H. Black.
Wm. Fluery.
Automatic Bldg. Block Machine Co., 119-121 Liberty St., Jackson, Mich.
W. T. Smith.
J. Hunter.
L. McGowan.
L. H. Scott.
C. F. Scott.
A. M. Haight.
P. F. Tall, 3172 N. Capitol Ave., Indianapolis.
J. E. White, 132 La Salle St,, Chicago.
Modern Construction Co., 110 Mason St., Milwaukee.
O. B. Hutchens.
R. E. Hutchens.
A. W. Friske.
C. J. Farrar, Emerson Ave., Crafton, Ohio.
L. M. Goddard, La Crosse, Wis.
H. B. Stephens, Contractor, Eaton, Ohio.
Sandusky Portland Cement Co., Sandusky, Ohio.
S. B. Newberry.
Ideal Concrete Machinery Co., South Bend, Ind.
G. B. Pulfer.
The Newark Artificial Stone and Plaster Co,, N. Williams St., Newark, Ohio.
John McNamara.
Tevis Bros., Humboldt and Commerce Sts., Milwaukee, Wis.
P. J. Bliffert, Jr.
J. L. Barr, Batavia, Ohio.
Hartwick Machinery Co., Washington St., E. Jackson, Mich.
Geo. D. Scheiffler.
Mrs. Scheiffler.
Eau Claire Concrete Co., Farwell and Maine Sts., Eau Claire, Wis.
Geo. W. Robertson.
J. W. Ross, Pres.
J. Fuhreman & Son, Oesoburg, Wis.
Jacob Fuhreman, Jr.
Jacob Fuhreman.
Flint Stone Co., 202 National Ave., Toledo, Ohio.

F. K. Hogne.
Cement Brick Co., Port Huron, Mich.
B. S. Roberts.
E. H. Crowell, Crown Point, Ind.
Diamond Cement Machine Co., Deshler, Ohio.
S. A. Jones.
David Hospins.
Piqua Artificial Stone Co., Wood St., Piqua, O.
C. E. Martin.
Lima Artificial Stone Co., Lima, Ohio.
Val Heil.
Ch. Tinnier.
John Locher.
St. Catharine's Building & Paving Co., Ltd., St. Catharine, Ont. Canada.
Chas. F. Roland.
W. H. Swazey.
347. P. C. McArdle, 797 W. Van Buren St., Chicago, Ill.
Kankakee Artificial Stone Co., 224 Court St., Kankakee, Ill.
H. O. Van Meter.
John Devere.
Wapakoneta Cement & Block Co., Wapakoneta, Ohio.
H. C. Wentz.
William Runkle.
American Tile & Artificial Stone Co., Americus, Ga.
O. P. Wallis.
Chickamauga Cement Co., Chattanooga, Tenn.
W. P. D. Moross.
Concrete Construction Co., Rock Island, Ill.
C. E. Bryan.
George W. De Smet, 317 Chamber of Commerce Bldg., Chicago, Ill.
Albert Moyer, Flat Iron Bldg., New York City.
Kennedy & Lowry, 38 Congress St., Detroit, Mich.
C. C. Lowry.
D. M. Kennedy.
Illinois Steel Co., Cement Dept., The Rookery, Chicago, Ill.
J. C. Van Dorn, Odd Fellows' Bldg., St. Louis, Mo.
Blanc Stainless Cement Co., 1 Madison Ave., New York City.
James Maxwell Carrere.

Standard Machine Co., Kent, Ohio.
A. L. Post.
Elmhurst-Chicago Stone Co,. Elmhurst, Ill.
Wm. Hammerschmidt.
R. Hammerschmidt.
Walton Granolithic Stone Co., 2500 E. 18th St., Kansas City, Mo.
F. S. Phipps.
Phillip Schaller, Sac City Concrete Stone Co., Sac City, Ia.
Geo. M. Whitcomb, Desplaines, Ill.
Jos. Schall, 820 Elson Ave., Chicago, Ill.
J. J. Flanders, Glenco, Ill
Metropolitan Stone Co., 1 Madison Ave., New York City.
Edward R. Diggs.
American Hydraulic Stone Co., Denver, Colo.
Will Scoutt, Chicago, Ill.
Ideal Machinery Co., So. Omaha, Neb.
D. M. Click.
Dexter Portland Cement Co., Nazareth, Pa.
Richard K. Meade.
Stevens Stone Co., Akron, New York.
Uriah Cummings.
Elyria Plaster Co., Elgin, Ohio.
W. S. Griswold.
F. F. Martin & Co., Goodwin Blk., Beloit, Wis.
F. F. Martin.
Rock Produce, 431 Main St., Louisville, Ky.
Fred K. Devine.
B. F. Lippold.
Inkerman Bailey.
Blaw's Collapsible Steel Centering Co., 1414 Penn. Ave., Pittsburgh, Pa.
Jacob B. Blaw, Pres.
A. W. Winzenburg & Son, Wood's Blk., Sedalia, Mo.
A. W. Winzenburg.
Century Cement Machine Co., West Main St., Rochester, N. Y.
John N. Rauber.
Cunningham Bros., Brook, Ind..
W. S. Cunningham.

Western Lime & Cement Co.
No. 508 Pabst Bldg., Milwaukee.
Wm. C. Lantry.
R. Cook.
M. T. Ash.
Evanston Hydraulic Stone Co.
Evanston, Ill.
C. H. Bartlett.
D. McCann.
Pen. Coal & Supply Co., 211 Grand Ave., Milwaukee, Wis.
Edw. W.
Concrete Construction Co.
Gus Mosweck.
C. Vandesande.
The Schoeneman Cement Blk. Co., George, Iowa.
T. J. Coakley.
Nat. Bldg. Blk. & Machinery Co., Milwaukee, Wis.
T. B. Whitnall.
Chas. W. Kenney, 2353 W. Jackson St., Chicago, Ill.
Automatic Building Block Machine Co., Jackson, Mich.
R. Schullinany.
P. M. Wolf.
T. Shea, 19 Hampden St., Springfield, Mass.
Andrew J. Shea, 19 Hampden St., Springfield, Mass.
Milwaukee Concrete & Supply Co., Milwaukee, Wis.
Geo. Burridge.
Concrete Construction Co., Green Bay, Wis.
T. J. McGrath.
Chicago Portland Cement Co., Chicago, Ill.
J. U. C. McDaniel.
Simplex Mfg. Co., Jackson, Mich.
A. C. Dornfeld, Kenosha, Wis.
The Durolithic Co., Buffalo, N. Y.
W. W. Wade.
New Castle Artificial Stone Co., New Castle, Pa.
W. P. Hanna.
Marquette Cement Mfg. Co., 1513-14 Marquette Bldg., Chicago, Ill.
Robt. B. Dickinson.
Geo. J. Hommel, Am. Exp. Co., Milwaukee, Wis.

Marquette Cement Co., Chicago, Ill.
John A. Dunlap.
St. Louis Expanded Metal Fireproofing Co., 606 Century Bldg., St. Louis, Mo.
Walt C. Berry.
Peerless Brick Mach. Co., 100 Lumber Exchange, Minneapolis, Minn.
L. V. Thayer.
Patrick Murphy.
Ideal Cement Block Machine Co., South Bend, Ind.
J. W. Cooper, Minneapolis, Minn.
C. D. Higgins, Aberdeen, S. D.
Hayden Automatic Block Machinery Co., 112 W. Broad St., Columbus, O.
Kirk H. Brown.
Chicago Portland Cement Co., Stock Exchange Bldg., Chicago, Ill.
W. F. Main.
The Pettyjohn Co., 603 N. 6th St., Terre Haute, Ind.
L. P. Dunn.
E. H. Thompson, University Place, Neb.
Western Lime & Cement Co., Milwaukee, Wis.
E. J. Sigwalts, N. W. Lime Co., St. Paul, Minn
F. C. Bailey.
Akron Artificial Stone & Construction Co., Akron, N. Y.
F. M. Jackson.
Illinois Steel Co., Chicago, Ill.
H. S. Backus.
M. N. Lovewell, Chicago, Ill.
Art Stone Supply Co., Wausau, Wis.
C. A. Nutter.
Fred G. Boyden, Bradford, Ill.
Automatic Block Machine Co., Jackson, Mich.
M. J. McGowan, Avoca, Pa.
Lora P. Hutto, Sharpsville, Ind.
The Sanitary Chemical Co., 721 W. Washington Ave., Indianapolis, Ind.
G. G. Fry.
H. S. Quick, 725 Lemcke Bldg., Indianapolis, Ind.

Freeport Concrete Construction Co., 111 Spring St., Freeport, Ill.
C. H. Carlon, 910 1st Ave., E. Oskaloosa, Iowa.
Henry Eilers, Burlington, Iowa.
Fred Goepper, 429 N. Holmes Ave., Indianapolis, Ind.
Welch & Minnich, Nicholasville, Ky., S. R. Minnich.
Portsmouth Cement Block Co., Portsmouth, Iowa.
W. E. Waterman.
Ed. Fennelly, Ashland, Wis.
W. J. Genthner, Dispatch, N. Y.
Cement Pressed Brick Co., Benton Harbor, Mich.
J. D. Luttrell.
L. R, Leppler, 185 Dearborn St., Chicago, Ill.
Chas. Harriman, 12 Odell Ave., Yonkers, N. Y.
Jacksonville Sand Cement Brick Co., Jacksonville, Ill.
W. H. Cocking.
Jas. Shearer, Collingwood, Ont.
American Carpenter & Builder, Chicago, Ill.
H. E. Trams.
O. F. Bybee.
Neola Cement Block & Const. Co., Neola, Ia.
J. H. Cupp.
M. Kammerer, Fairbury, Ill.
The Winget Concrete Machine Co., 482 N. High St., Columbus, Ohio.
D. T. Kraner, 6812 Hamilton Ave., Pittsburg, Pa.
C. E. Lander, Viroqua, Wis.
Pennsylvania Cement Co., 26 Cortland St., New York, N. Y.
W. W. Bale.
Charleston Building Block Co., Charleston, W. Va.
L. B. LeRoy.
Phillips Lime & Coal Co., Burlington, Ia.
P. H. Phillips.
P. O. Krottnauer, 226 La Salle St., Chicago, Ill.
Chas. F. Nesbit, Dixon, Ill.
Brillion Concrete Works, Brillion, Wis.
John Koche.
Vulcanite Portland Cement Co., Flatiron Bldg., New York City.
Albert Moyer.
S. T. Henry, Engineering Record, New York.

W. F. Roney, Grand Island, Neb.
W. J. Donahue & Co., 402 Free Press Bldg., Milwaukee.
Geo. W. Clark, Wausau, Wis.
Stromsberg Concrete Stone Works, Stromsberg, Neb.
F. C. Halden.
C. H. Carter, Peotone, Ill.
Hannaford Cooperstown Concrete Co., Hannaford, N. D.
S. H. Berg.
Concrete Sand & Stone Co., Youngstown, O.
A, A, Pauly.
Clews & Co., South Bend, Ind.
Ideal Concrete Machinery Co., South Bend, Ind.
Mentor Wetzstein.
W. A. Stewart, Antigo, Wis.
P. F. Tall, 3172 N. Capital Ave., Indianapolis, Ind.
Western Whiting & Mfg. Co., Elsaw, Ill.
Alex. Marshall.
P. P. Comoli, sole prop. Corn Palace Cement Works.
Sioux City, Ia.
Pandora Cement Block Co., Pandora, Ohio.
Fred Gratz.
Power & Mining Machinery Co., Cudahy, Wis.
F. C. Dunham.
Licking Art Stone & Const. Co., Newark, Ohio.
Wm. Chambers. Garden City Sand Co., Chicago, Ill.
James F. Lee & Son, 207 W. Locust St., Dubuque, Iowa.
W. H. Minahan, Wauwatosa, Wis.
J. Duncan, Salina Hydraulic Stone & Brick Co., Salina, Kansas.
Wm. Millen, 2825 W. 1st St., Duluth, Minn.
Stringer Machine Co., Jackson, Mich.
Eber S. Peck.
H. M. Hack, Kankakee, Ill.
H. T. Boyden, Builders' Supply Co., Buckhannon, W. Va.
Fremont Concrete Stone Co., Fremont, Neb., A. M. Helt, Manager.
D. McDonald, 616 Michigan St., Petosky, Mich.
F. A. Stare, Frankfort, Ind.
Joseph Trompeter, Peru, Ill.
Battjes Fuel & Building Material Co., Grand Rapids, Mich.

Nicholas Battjes.
Frank Battjes.
John McBride, 545 Chicago St., Elgin, Ill.
O. F. Smith & Son, Broadhead, Wis.
E. A. Smith.
Usona Manufacturing Co., Urbana, Ill.
Fred Eiklor.
Toledo Cement & Block Co., Toledo, O.
A. J. Johnson.
Thomsen & Smart, 118 Oakley Ave., Waukegan, Ill.
R. L. Smart.
D. C. Holloway, Lombard, Ill.
Keune Bros., Hika, Wis.
Wm. A. Keune.
C. D. Corey, 626 Elm St., Rockford, Ill.
Rockford Concrete Construction Co., Rockford, Ill.
T. E. Gaffney.
Oshkosh Concrete Construction Co., Oshkosh, Wis.
Eli Defuet.
L. A. Young, North Manchester, Ind.
W. P. Nees, Wellington, Ont.
J. W. Cotter 617 State St., Appleton, Wis.
Cleveland Concrete Building Block Co., 1010 Rockefeller Blk. Cleveland, O.
R. W. Russell.
Palmer Concrete Hollow Block Co., 40 N. Delaware St. Indianapolis, Ind.
C. F. Childer.
Curt. M. Treat, 77 Jackson Blvd., Chicago, Ill.
J. O. Watterworth, 512-514 Troy Bldg., Duluth, Minn.
E. F. Facemire, Edinburg, Ind.
E. E. Truesdell, Belvidere, Ill.
Elyria Lumber Co., Elyria, Ohio.
H. B. Hecock.
Northwestern Steel & Iron Works, 1214 1st Ave., Eau Claire, Wis.
L. A. Tarr, Edinburg, Ind.
Clyde Clark, North Lake St., Warsaw, Ind.
Fred S. Clark, North Lake St., Warsaw, Ind.
Jas. F. Pittner, Ottoville, Ohio.

Western Lime & Cement Co.
A. W. Grider.
R. J. & W. M. Boyd Construction Co., Kansas City, Mo.
W. M. Boyd.
Norwood Concrete Block Co., Hyde Park, Cincinnati, O.
H. M. Ormsby.
Nick Lauer, Ottoville, Ohio.
Salina Hydraulic S. & B. Co., Santa Fe Ave.,Salina, Kansas.
F. C. Henry.
Edward T. Cairns, 169 La Salle St., Chicago, Ill.
John Anderes, Wausau, Wis.
Arthur W. O'Keefe, Plymouth, Ind.
Wm. L. Wallace, Roanoke, Ind.
C. W. Menefee, Thomas St., Ft. Wayne, Ind.
Cement Construction Co., Terre Haute, Ind.
W. R. Kennedy.
McGinnis & Whitlock, Indiana St., Terre Haute, Ind.
E. W. Whitlock.
Manufacturers of Bldg. Block Machinery, Terre Haute, Ind., 830 Collett Ave.
P. H. Brewster.
Robt. Cutts, Lee, Ill.
Elmer Lower, Rochelle, Ill.
The New Way Motor Co., Lansing, Mich.
A. Vibber.
G. J. Conyne.
A. W. Early, Rock Fall, Ill.
Welch & Hawley, Wibona, Ill.
C. J. Welch.
William Porten Co., 569 Capitol Blvd., St. Paul, Minn.
William Porten.
Samuel Isely, Monroe, Wis.
W. O. McKinny, Piper City, Ill.
Ed. Stott, Darlington, Wis.
Wisconsin Brick Co., Madison, Wis.
E. W. Smythe.
Miss J. Kirchoff, Milwaukee.
Ella King, Milwaukee.
Lou Davis.
Mrs. R. Weber, Milwaukee.

Mrs. S. Hackey, 305 4th St., Milwaukee.
National Building Block Co., 211 Grand Ave, Milwaukee, Wis.
Wm. Bannen.
Penn. Coal & Supply Co., Milwaukee.
Jno. L. Hart.
W. C. Bensemann, 31 Hathaway Bldg., Milwaukee.
James Sinclair, Marquette, Mich.
Milwaukee Concrete Supply Co., Milwaukee.
C. Hansen, Architect.
G. W. Burr.
W. M. Munson, Jr., Mitchell, Ind.
Robt. F. Prengel, 881 Humboldt Ave., Milwaukee,
Williams Mfg. Co., 301 Journal Bldg., Chicago, Ill.
W. O. Williams.
Thos. H. Sherman, Terrace Pl. and 20th St., Brooklyn, N. Y.
J. L. Johnson, West Union, Iowa.
E. C. R. Scott, 1637 Asylum Ave., Racine, Wis.
A. D. Mackay & Co., Chicago, Ill.
A. D. Mackay
Pettyjohn Co., Terre Haute, Ind.
Geo. L. Barnes.
National Bldg. Blk. Co., 211 Grand Ave., Milwaukee.
F. W. Hadfield.
Anchor Concrete Stone Co, 312 Main St., Rock Rapids, Iowa.
Chas. W. Bradley.
Morriss Construction Co. Granite City, Ill.
A. W. Morriss.
R. A. Morriss.
C. E. Lipton, 150 Franklin St., Harrisonburg, Virginia.
Elisha Hall, Princeton, Wis.
Thomas Darcey, Watertown, Wis.
Gus Frey, 829 1st St., Milwaukee.
Terre Haute Coal & Lime Co., Terre Haute, Ind.
J. W. Landrum.
Practical Cement Blk., 23 E. Market, Indianapolis.
A. E. Bradshaw.
Wolverine Portland Cement Co., 902 Chamber of Commerce, Chicago, Ill.

W. E. Cobean.
Kimpel Land Co., 239 Third St., Milwaukee, Wis.
W. A. Kimpel.
A. Heep, 651 8th St., Milwaukee.
The Schmitt Construction Co., Peoria, Ill.
J. P. Schmidt.
C. J. Kramer, 277 34th St., Milwaukee.
Jansen & Zreller, Pekin, Ill.
Easy Block Handlers,Appleton, Wis.
W. H. Fischer.
Chas. Donnelly, 481 Cass St., Milwaukee.
"Construction News," Chicago, Ill.
E. S. Hanson.
Wm. Hanner, 81 4th Ave., Beloit, Wis.
Municipal Engineering & Const. Co., Chicago, Ill.
Herman Uesling, Winthrop Harbor, Ill.
Omer Brandon, 5644 University Ave., Indianapolis, Ind.
Milwaukee Concrete & Supply Co., Niles, Wis.
William Chambers.
Robt. Higgs.
Art. F. Partridge.
Coltron Mfg. Co.
Geo. Merrill.
C. C. Helling.
Burnham Brick Co., Jackson St., Milwaukee.
W. J. Morgan.
John F. Burnham.
N. E. Good, 165 Center St., Ashtabula, Ohio.
Atlas Portland Cement Co., 30 Broad St., New York, N. Y.
B. L. Swett.
Western Builder Pub. Co., Montgomery Bldg., Milwaukee, Wis.
K. K. Albert.
Municipal Engineering Co., Commercial Club Bldg., Indianapolis, Ind.
W. P. Cosgrove.
F. T. Randall.
William Fortune.
The Milwaukee Sentinel.
The Western Builder, Milwaukee, Wis.

P. L. Johnson.
B. M. Toutloff.
Cement Machinery Mfg. Co.,
W. F. Roney.
C. B. Foster.
W. S. Farrar.
J. W. Sanderson.
Chas. E. Niend.
Winget Concrete Mach. Co., Columbus, O.
Tom Kraner.
A. Clark.
J. F. Angell.
E. B. McDowell.
Simpson Cement Mold Co., 351 Marshall Ave., Columbus, O.
H. G. Simpson.
Simplex Mfg. Co., 124 Cortland St., Jackson, Mich.
C. Whitney.
Berthelet Construction Co., Milwaukee.
C. L. Fortier.
A. Ellefson, 717 Gar. Ave., Fort Smith, Ark.
The Hayden Auto. Block Mach. Co., 112 W. Broad St., Columbus. O.
C. E. Ottman.
Municipal Eng. & Contr. Co., Chicago, Ill.
C. E. Bathrick.
T. M. Meek.
Knickerbocker Co., Jackson, Mich.
R. B. Coltrin.
The New Way Motor Co., Lansing, Mich.
C. L. McHenry.
W. H. Newbrough.
A. N. Fairchild, 643 Shepard Ave., Milwaukee, Wis.
Milwaukee Concrete & Supply Co., Milwaukee.
W. L. Stimple.
Iowa Building Block Mach. Co., Waterloo, Iowa.
H. L. Green.
J. L. Shannon.
Wisconsin Hollow Concrete Wall Co., 314 Broadway, Milwaukee.
Alfred Meurer.
White Cement Machinery Co., Jackson, Mich.

C. O. White.
Robert Campbell.
National Builder, 358 Dearborn St., Chicago, Ill.
A. Faigher.
E. C. Schmidt, Cincinnati, Ohio, Cinti. Enquirer, etc.
The Chase Fdy. & Mfg. Co, Columbus, Ohio
S. M. Chase.
Welch & Minnich, Nicholasville, Ky.
Mrs. T. R. Welch.
E. W. Seamans Co., Grand Rapids, Mich.
C. Marsman.
The T. O. Eichelberger Co., Dayton, Ohio.
J. W. Popenoe.
T. O. Eichelberger.
H. A. Schlick.
Wm. Hughes.
J. C. Collett.
J. W. Popenoe.
Milwaukee Concrete & Supply Co., Milwaukee, Wis.
J. S. Sanborn.
Frank Ehlert.
M. Dix.
854. C. Herman Dorner, 1922 Cedar St., Milwaukee, Wis.
The Edmondson Machine Co., South Bend, Ind.
855. J. H. Willeg, Plymouth, Ind.
Milwaukee Concrete & Supply Co.
Mr. Bond.
Mr. Lauman.
Mr. Hahn.
Mrs. W. J. Genthner.
Contractors' Supply & Equipment Co., 520 Old Colony Bldg., Chicago, Ill.
Jno. F. Pearce.
The Schoeneman Cement Block Co., George, Iowa.
W. R. Dallman.
T. J. Coakley.
Jacksonville Sand Cement Brick Co., Jacksonville, Ill.
Otto Hoffman.
F. K. Mayne.
Chicago Portland Cement Co., Chicago, Ill.

J. W. Woodruff.
E. E. P. Truesdell, Belvidere, Ill.
Winget Concrete Machine Co., Columbus, O.
S. M. Coe, Indianappolis, Ind.
James S. Macdonald, 147 Jackson St., Milwaukee, Wis.
Western Builder.
C. C. Jacobs, Wauwatosa, Wis.
Chas. Ellis Malig. 758 3d St., Milwaukee, Wis.
A. C. Fuge, West Bend, Wis.
S. J. Dowling.
Jno. Molitor, Architect, 160 Washington St., Chicago, Ill.
American Carp. & Bldr., Chicago, Ill.
Wm, Renther.
Hoosier Cement Post Machine Mfg. Co., and Ideal Cement Post Co., Elkhart, Ind.
C. L. Catherman.
Edwin Osgood, 205 N. Euclid Ave., Oak Park, Ill.
J. A. Sodestrom, Sac City, Iowa.
Eureka Mach. Co.
H. F. Abbott.
Rudolph P. Miller, 141 E. 40th St., New York City.
Berthelet Construction Co., Milwaukee, Wis.
Aug. Luengemann.
Bert. Perrigo.
Chas. Buckwiller.
C. V. Koch.
N. A. Christiansen.
B. K. Miller.
J. D. Mitchell, 44 Lombard Bldg., Indianapolis, Ind.
H. S. Palmer Building Block Co., R. J. Schwab, Milwaukee, Wis.
Rock Products, 431 Main St., Louisville, Ky.
Fred K. Irvin, Editor.
Ben. F. Lippold.
Inkerman Bailey.
C. L. Wilber, 717 18th St., Denver, Col.
Emil Court, 594 Prospect St., Herold, Wis.
J. W. Cotter, 617 State St., Appleton, Wis.
W. A. Lewis, 182 Wisconsin St., Milwaukee, Wis.
H. Becker, Grand Ave., Milwaukee, Wis.

Bedger Cement Stone Co., 111 Mason St., Milwaukee, Ohio.
C. J. Poetsch, City Engineer, Milwaukee, Wis.
Jacob Smith, Cleveland, Ohio.
Atlas Portland Cement Co., 30 Broad St., New York City.
Crescent Cement Block Mfg. Co., Deshler, O.
C. L. Catherman, Elkhart, Ind.
G. F. Shreve, 308 20th St., Milwaukee, Wis. Mason & Contractor.
Riesen & Wilke, 970 1st St., Milwaukee, Wis. Mason & Contractor.
The Winget Machine Co., 482 N. H. St., Columbus, Wis.
Mrs. F. K. Hogne.
Sheldon Bros., 617 11th Ave., Maywood, Ill.
Sheldon Bros., 617 11th Ave., Maywood, Ill.
Victor Concrete Mfg. Co., Janesville, Wis.
John Rogers.
Victor E. Rogers.
Rock Co. Concrete Stone Co., Janesville, Wis.
G. N. Fisher.
Berthelet Construction Co., 135 Grand Ave., Milwaukee, Wis.
R. Hartman.
S. E. Czerwinski.
Thos. E. Haye.
Rudolph Zek, 1321 Fredericka St., Milwaukee, Wis.
Milwaukee Concrete Supply Co., Milwaukee, Wis.
Atlas Portland Cement Co., 30 Broad St., New York City.
Thos. M McGiff.
J. L. Austin.
Geo. C. Ehlers.
O. J. Schoeneciar.
Atlas Portland Cement Co., Hannibal, Mo.
D. B. Pierson.
Manufacturer's Record Pub. Co., Baltimore, Md.
John Glass, Western Representative.
Granite City Lime & Cement Co., Granite City, Ill.
A. H. Eisenmenger.
Milwaukee Concrete & Supply Co., Milwaukee, Wis.
G. Becher.
Bert Perigo.
George Ness, 251 Third St., Milwaukee, Wis.

LIST OF EXHIBITORS.

American Carpenter and Builder, Chicago, Ill.
Atlas P. C. Co., New York, N. Y.
Aut. Bldg. Blk. Mach. Co., Jackson, Mich.
Barker & Nighswander, Toledo, Ohio.
Blanc Stainless Cem. Co., New York, N. Y.
Castalia P. C. C., Castalia, Ohio.
Cement & Engineering News, Chicago, Ill.
Cement Machine & Mfg. Co., Burlington, Iowa.
Century Cement Mach Co., Rochester, N. Y.
Chase Fdy. & Mfg. Co., Columbus, Ohio.
Chicago Portland Cem. Co., Chicago, Ill.
Coltrin Mfg. Co., Jackson, Mich.
Concrete Pub. Co., Detroit, Mich.
Construction News, Chicago, Ill.
Driscoll & Gochnauer, Appleton, Wis.
The Durolithic Co., N. Tonawanda, N. Y.
Edison P. C. Co., Philadelphia, Pa.
The T. O. Eichelberger Co, Dayton, Ohio.
Fairbanks Morse Co., Milwaukee, Wis.
Hartwick Mach. Co., Jackson, Mich.
Hayden Aut. Blk. Mac. Co., Columbus, Ohio.
Ideal Concrete Mach. Co., South Bend, Ind.
Illionois Steel Co., Chicago, Ill.
Indestmetible Post Co., Chicago, Ill.
International Fence & F. P. Co., Columbus, Ohio.
Iowa Bldg. Blk. Mac. Co., Waterloo, Iowa.
Jaeger Aut. Mach. Co., Columbus, Ohio.
Knickerbocker Co., Jackson, Mich.
T. M. Lehew & Son, Wausau, Ind.
Lehigh P. C. Co., Allentown, Pa.
Marquette Cement Mfg. Co., Chicago, Ill.
Metropolitan Stone Co., 1 Madison Ave., New York.
Milw. Concrete & Supply Co., Milwaukee, Wis.
Miracle Pressed Stone Co., Minneapolis, Minn.

Morgan & Burnham, Milwaukee, Wis.
Municipal Eng. & Con. Co., Chicago, Ill.
National Builder, Chicago, Ill.
Newway Motor Co., Lansing, Mich.
Northwestern Expanded Metal Co., Chicago, Ill.
H. S. Palmer Co,, Washington, D. C.
Peerless Brick Mach. Co., Minneapolis, Minn.
Penn Cement Co., New York, N. Y.
Perfection Block Mach. Co., Minneapolis, Minn.
Pettyjohn Company, Terre Haute, Ind.
Queen City Brick Mach. Co., Traverse City, Mich.
Reading Brick Mach. Co., Reading, Pa.
Ricketson Mineral Paint Wks., Milwaukee, Wis.
St. Louis Expanded Metal Fireproof Co., St. Louis, Mo.
Sandusky Portland Cement Co., Sandusky, Ohio.
Sanitary Chemical Co., Indianapolis, Ind.
Schoeneman Cem. Blk. Co., George, Iowa.
E. W. Seamans, Grand Rapids, Mich.
Simplex Mfg. Co., Jackson, Mich.
T. L. Smith Co., Milwaukee, Wis.
J. A. Sodestrom, Sac. City, Iowa.
South Bend Mach. Mfg. Co., South Bend, Ind.
Standard Mach. Co., Kent, Ohio.
Standard Sand & Mach. Co., Cleveland, Ohio.
Sterling Wheelbarrow Co., Milwaukee, Wis.
E. W. Dowagaic, Mich.
Stevens Cask Stone Co., Harvey, Ill.
Western Portland Cement Co., Milwaukee, Wis.
William Moore Co., Chicago, Ill.
Winget Concrete Mach. Co., Columbus, Ohio.
Wisconsin Hollow Con. Wall Co., Denver, Colo.
Youngstown Expanded Metal Fireproofing Co., Youngstown, O.

MINUTES OF THE MEETINGS OF THE EXECUTIVE BOARD.

FINANCIAL STATEMENT.

The reports of the Secretary to the Executive Board and the receipts of the Treasurer and vouchers issued to cover expenditures show the following summary when classified according to the system adopted by the Board:

INCOME.

By Amt. receved from sale of space 1905 Convention.		$911.00	
" " " cartage "		23.00	
" " " advertising "		11.00	
" " " freight charges "		29.50	
" " " membership fees "		805.00	
" " " fees validating railroad certificates		59.75	$1839.25

EXPENDITURES.

To office expenses		$252.79	
" traveling expentes		94.08	
" stationary and printing		181.65	
" postage, telegrams	$141.14		
" Treas. bond	7.50	148.64	
" Salaries and rent		376.26	
" exhibit expenses		110.80	
" Convention expenses		514.10	$1678.32
	Bal. in hands of Treas.		160.93

It will be noted that no salaries have been paid to any officials. The items of traveling expenses include only the expenses of the Secretary, which were voted to him by the Board in lieu of salary. The other members of the Board have paid their own expenses to the meetings of the Board which were held in Norfolk, Va., April 20th, Atlantic City, September 1st, and at New York December 19th, and 20th.

MINUTES.

In accordance with the provisions of the constitution the minutes of the Executive Board's meetings are presented as a part of this report as follows:

MINUTES OF THE MEETING HELD AT NORFOLK, VA., APRIL 20th, 1905.

A meeting of the Executive Board of the National Association of Cement Users was held at Norfolk, Va., April 20th, 1905 at 1:36 P. M. Those present were: John P. Given. Chas. C. Brown, A. Monsted, A. S. J. Gammon, W. W. Benson and Richard L. Humphrey. John H. Fellows and H. C. Quinn arrived later.

The question of Mr. Given's resignation as president was taken up legally according to the instructions of the Association, Vice-President Mr. Monsted was called to the chair. Mr. Benson moved that Mr. Given's resignation be accepted and that Mr. Humphrey be elected to fill the vacancy. By unanimous vote Mr. Given's resignation was accepted and Mr. Humphrey elected President.

The financial report of the Secretary was read and referred to the auditing committee.

Advertising rates in the Proceedings were then fixed as follows:

Inside front cover	$25.00
Inside back cover	20.00
Outside back cover	25.00
Inside page	15.00
Half page	8.00
Quarter page	5.00
Eighth page	2.00

It was decided to charge a fee of $2.00 to each non-member who desired to attend the Convention the same to be credited on the membership fee should he afterwards become a member; distinguishing colored badges to be provided for members and non-members.

The Secretary was empowered to purchase needed office furniture, have a stenographer and pay all necessary office expenses.

Mr. Humphrey was authorized to represent the association and to act as he thinks best as a member of the National Advisory Board on Fuels and Structural Materials.

The President was authorized, by motion of John H. Fellows; to select a committee to act for the Board in emergencies requiring immediate attention.

The Secretary was authorized to render a voucher for his expenses in attending the Board Meeting at this time the same to apply on his future salary account. Members of the Board were requested to send statements of expenses to Secretary for future allowance when possible.

The Treasurer was instructed to give bond for $1000.00 and to render a bill for this expense; the details were left to the President and who was authorized to appoint trustees for the Treasurer's bond.

On motion, John H. Fellows, the incorporation of the Association was referred to the President and Secretary and a third member to be appointed by the President.

Richard L. Humphrey, John H. Fellows, and A. Monsted were appointed Trustees for the Treasurer's bond.

It was decided to hold the next meeting of the Board of Directors at Atlantic City, about the first week in September, the exact date to be fixed by the President and Secretary.

The Secretary was instructed to prepare By-Laws to govern the Executive Committee and to report them at the next meeting of the Board. He was also instructed to investigate designs and costs of badges for members.

The organization of sections on Fire-proofing and Insurance, and Law and Ordinances was discussed.

Several changes were suggested in the Constitution. The 2nd paragraph of Section 1 of Article 2 to provide that a company shall designate which representative shall be the delegate to the Convention and shall cast the vote for the Company. In the 1st section of Article 3 a change was discussed as follows: that the phrase "four general vice-presidents" be left out and the vice-presidents be named in order of their sections. Section 7 of Article 3 to read: Architectural Designs; Artificial Stone; Pavements; Plain and Re-inforced Concrete; Testing of Cement and Cement Products; Machinery; Fire-proofing and Insurance rates; Laws and Ordinances; Section 5 of Art. 3 to read, "The treasurer of this Association shall disburse funds only on warrant drawn by the Secretary and countersigned by the President. Sec. 1 of Art. 4 to be changed to read; *or* at such other times as the Association may determine

instead of *and* at such other, etc. On motion these and other suggestions of changes were referred to the next meeting of the Board.

The report of the auditing committee was accepted and filed.

The Secretary was instructed to extend a vote of thanks to the citizens of Norfolk for the cordial reception and the entertainment extended the members of the Executive Board.

Approved September 1st, 1905.

Chas. C. Brown, Secy.

MINUTES OF THE MEETING AT ATLANTIC CITY, N. J. SEPTEMBER 1st, 1905.

The meeting of the Executive Board of the National Association of Cement Users held at Atlantic City, N. J., Sept. 1st, 1905 was called to order by the President, Richard L. Humphrey, at 10:00 A. M. The members present were Richard L. Humphrey, Chas. C. Brown, W. W. Benson and John Fellows. E. D. Boyer arrived later.

The minutes of the last meeting were read and approved.

The following firms were elected members of the Asso-tion:

Toch Brothers, New York City.
Lancaster Hollow Concrete Block Co., Lancaster, Pa.
S. Engleberth, Bersford S. D.
J. F. Villalta, C. E., Barcelona, Spain.
Elwood C. Benner, Sargent, Neb.
Henry Hansberger, Millersport, Ohio
Chicago Portland Cement Co., Chicago, Ills.
Alpha Portland Cement Company, Easton, Pa.
The American Clay Machinery Co. Willoughby, Ohio.
American Cement Company, Philadelphia, Pa.
Turner Construction Company, New York, N. Y.

The Secretary's financial report was accepted and referred to a committee consisting of Messrs Fellows and Benson; whose report was subsequently approved and ordered filed.

President Humphrey announced the resignation of A L Goetzmann, 1st Vice President of the Association and upon motion of Mr. Benson, Mr Goetzman's resignation was accepted with regret, and Mr. Merrill Watson of the Associated Expanded Metal Engineering Companies of New York was elected to fill the vacancy.

President Humphrey reported concerning the National Advisory Board on Fuels and Structural materials. Sixteen Societies are included in the Board C B. Dudley, President of the American Society of Testing Materials is President of the Board and Richard L. Humphrey, President of the Na-

tional Association of Cement Users is Secretary. The Board was requested to present at the next Convention a resolution in aid of securing an appropriation by Congress for the purposes in testing cement, mortar and concrete.

The Board voted to incorporate the Society and Mr. Fellows, President Humphrey and Secretary Brown were appointed a committee to prepare the necessary articles of incorporation and By-Laws.

The local committe for the Milwaukee Convention was appointed consisting of J. P. Sherer, Chairman, A. Monsted, John Wharrery, R. J. Schwab, Western Portland Cement Company, and such others as these persons might add to the Committee.

The Committee on Advertising and Exhibits was appointed consisting of: Albert Moyer, of New York City, C. F. Berger, of Chicago, J. F. Angell, of Columbus, D. N. Harper, of Detroit, and Secretary Brown. The Committee was given the power to add to its numbers as it deemed advisable.

The Emergency Committee appointed at the last meeting was given power to act as it found necessary regarding the publication of the Proceedings of the next Convention.

The program for the next Convention was outlined and the question of exhibits at the Convention and advertising for the Proceedings was discussed.

The President appointed the following Committees on Laws and Ordinances and on Fire-proofing and Insurance. The Committee on Laws and Ordinances was: C. T. Purdy, H, C. Henley, W. J. Scoutt, R. P. Miller and James G. Houghton. The Committe on Fire-proofing and Insurance was: A. L. Johnson, E. T. Cairns, J. W. Sanderson, O. U. Miracle and O. U. Crosby.

MINUTES OF THE MEETING AT NEW YORK, DECEMBER 19th, 1905.

The Executive Board met at the House of the Civil Engineers in New York City at 10:30 A. M., December 19th, 1905. Those present were President Richard L. Humphrey, Merrill Watson, John H. Fellows, E. D. Boyer, W. W. Benson, A. S. J. Gammon, and Secretary Charles C. Brown.

The minutes of the last meeting were read and approved.

An enameled pin for members of the Association at the cost of about twenty cents was ordered by vote of the Board.

On motion of Mr. Watson the action of the President and Secretary in the publication of the proceedings was approved.

The Secretary was instructed to reply to all letters which he had received concerning invitations for the next Convention stating the needs of the Convention and asking for a statement of what the organization extending the invitation would guarantee in the way of providing accommodation for the convention.

The Treasurer was instructed to close his report on the 1st of January if possible and to pay all bills audited to that date or as near that date as the circumstances would permit.

A Committee of three was appointed, consisting of the President, Secretary and a third member of the Board of their own choosing, to act as an emergency committee, to act on matters concerning the next Convention and the program arrangements for the Convention with full power.

Messrs. Benson, Fellows, and Watson were appointed a Committee to audit the accounts of the Secretary and Treasurer on the date of closing of the same.

The President, Secretary and Treasurer were instructed to prepare annual reports.

The matter of the place of meeting was discussed very fully and communications by telephone and telegraph were held with Columbus, Chicago, and Milwaukee. It was the opinion of all the members of the Board except the Secreary,

that the meeting place should be changed to Columbus, Ohio.

The Secretary reported regarding incorporation of the Society and it was voted to proceed at once and that by-laws be prepared for presentation to the Association. The details of this matter were referred back to a Committee appointed at a former Board meeting.

It was resolved that a manager should have charge of the exhibit space at the Convention and should be there at least a week prior thereto and locate exhibitors in order of application for space and that he remain after the Convention until the exhibits are all out and the accounts all closed.

New members were elected as follows:

Stuart & O'Brien, Paris, Ky.
Worswick Street Paving Co., Fresno, Cal.
Stocker Gravel & Arti. Stone Co., Highlands, Ill.
Frost & Sons, Jerseyville, Ill.
Penna. Cement Company, New York City.
Wigget Concrete Machine Co., Columbus, Ohio.
Harmon S. Palmer Hollow Concrete Blk., Co., Washington, D. C.
C. A. P. Turner, Minneapolis, Minn.
Wm. Dickerson, Chicago, Ill.
Henry S. Spackman Engineering Co., Philadelpeia, Pa.
Astral Drier Company, Indianapolis, Indiana.
E. B. Kelley, New York City.
G. D. Rowell & Son, Appleton, Wis.
H. C. Henley, St. Louis, Mo.
Castalia Portland Cement Co., Pittsburg, Pa.
Queen City Brick Machine Co., Traverse City, Mich.
The Pettyjohn Company, Terre Haute, Ind.
The Jeffrey Mfg. Co., Columbus, Ohio.
E. C. Mack, Alton, Ill.
A. L. Johnson, St. Louis, Mo.
John Driscoll & M. K. Gochnauer, Appleton, Wis.
The Jaeger Automatic Machine Co., Columbus, Ohio.
F. Brownell & R. H. Bowen, Keokuk, Iowa.
South Bend Machine Mfg. Co., South Bend, Indiana.
Karl A. Bracker, Dayton, Ohio.
Hartwick Machinery Company, Jackson, Mich.

H. C. Lansing, Wheeling, W. Va.

The Edison Portland Cement Company, Pittsburg, Pa.

St. Louis Hollow Concrete Blk. Construction Co., St. Louis.

Barker & Nighswander, Dayton, Ohio.

Western Lime & Cement Co., Milwaukee.

Wm. C. Langtry, Milwaukee, Wis.

Chas. R. Miller, Memphis, Tenn.

Nice, Rasor Company, Barberton, Ohio.

Peerless Brick Company, Minneapolis, Minn.

Henry Eickemeyer, Bay City, Mich.

St. Louis Expanded Metal Fire-proofing Co., St. Louis.

Meachem & Wright Co., Chicago, Ill.

T. M. Le Hew, Warsaw, Ind.

By motion a special rate of $5.00 for table space of the Proceedings of the meeting without charge.

On motion of Mr. Benson it was ordered that the $5.00 membership should permit as many delegates as the member desired, to enter the exhibit hall and that only members are entitled to entrance to the Convention halls.

Those not full members must pay a prescribed $2.00 fee for convention membership in order to enter the hall and to have their railroad certificate validated.

The meeting adjourned at 5;00 P. M. to meet at the office of Merrill Watson, at 12:00 noon December 20th.

The Executive Board of the National Association of Cement Users met on Tuesday noon, December 20th, at the office of Merrill Watson, 256 Broadway, New York City. Those present were President Humphrey, Messrs. Watson, Benson and Brown.

After hearing telegrams from Milwaukee and Columbus, the Board confirmed the informal action of the previous day, the Secretary alone dissenting, and selected Columbus, Ohio, as the place of meeting and instructed the secretary to stop at Columbus and make formal arrangements.

MINUTES OF THE MEETING AT MILWAUKEE, WIS., JANUARY 9th, 1906.

The meeting was called to order by President Richard L. Humphrey at 12:30 P. M. There were present Richard L. Humphrey, Merrill Watson, A. Monsted, W. W. Benson, A. L. Johnson, A. S. J. Gammon, and Secretary Chas. C. Brown.

The minutes of the last meeting were approved.

Mr. Monsted moved that as the Association is able to meet its obligations from its own Treasury, that the contribution of the American Association Cement Manufacturers be returned with thanks.

The President explained that, upon more complete knowledge of the provisions at Milwaukee and with knowledge of the provisions of the Constitution and the difficulties affecting a change at that late date, it appeared to him to be unwise to attempt to change the place of holding the second Convention and that he instructed the Secretary to continue with the arrangements at Milwaukee. On motion of Mr. Gammon this action of the President was approved.

The resignation of B. L. Simpson was received and accepted and Arthur N. Pierson was appointed to serve in his place.

The bond of the Treasurer was accepted and the fee therefore was ordered to be paid.

Milwaukee, Wis., January 9th, 1906.

The meeting was called to order by President Richard L. Humphrey at 10:30 P. M. There were present Richard L. Humphrey, Merrill Watson, A. Monsted, W. W. Benson, A. N. Pierson, A. L. Johnson, A. S. J. Gammon and Secretary Chas. C. Brown.

Form of By-Laws for incorporation of the Association were adopted.

Form of charter for incorporation under United States statute was adopted.

The Annual report of the Board was then adopted.

PROCEEDINGS INDIANAPOLIS CONVENTION:—The income for the year, derived from the proceeds from the Convention of

1905 together with the dues of the rather small number of members was hardly sufficient to pay the necessary expenses of the Association. It was not possible to publish the proceedings, therefore, without the additional revenue derived from advertisements. Advertisers were slow to respond and the Emergency Committee finding that the Association did not have funds enough to publish its proceedings, secured a contribution of Two hundred and fifty ($250.00) dollars to be used in defraying the cost of printing the volume, from the Association of American Portland Cement Manufacturers. Upon the recommendation of the Emergency committee, the Executive Board finding that the Association closed the year with enough money to meet all its bills returned the contribution with thanks. The volume is issued as this Convention assembles.

PLACE 1907 CONVENTION:—Invitations for the Convention have been received from Columbus, Ohio, the Jamestown Tercentennial Exposition, at Norfolk, Va., the Chicago Commercial Association, the Cincinnati League, and the Denver Convention League. Letters were sent to each of the bodies in accordance with the resolutions passed at the December Board meeting and full replies have been received from Columbus and the Jamestown Tercentennial Exposition, Cincinnati, Denver and Chicago.

INCORPORATION OF ASSOCIATION;—The Executive Board desires to state that as a matter of policy it has considered this organization in its broadest lines and has endeavored to protect all interests in its appointments and in all official actions affecting the future policy of the organization. The Board, feeling that the Association at every Annual Convention was receiving certain obligations and responsibilities in connection with the exhibits connected with the Annual Conventions deemed it wise to incorporate the organization thereby relieving the members from any financial obligation beyond their annual dues.

LIST OF MEMBERS.

Acme Cement Block Co., Wellsburg, W. Va.
Adams, Adolph, Kendallville Ind.
Alpha Portland Cement Co., Easton, Pa.
Alton Roofing & Artificial Stone Co., Alton, Ill.
American Cement Co., Philadelphia, Pa.
American Clay Machinery Co., Willoughby, Ohio.
Americus Tile & Artificial Stone Co., Americus, Ga.
American Hydraulic Stone Co., Denver, Colo..
Anchor Concrete Stone Co., Rock Rapids, Ia.
Arn, E. F., Kansas City, Kas.
Astral Drier Co., Indianapolis, Ind.
Atlas Portland Cement Co., New York City.
Atlanta Concrete Mfg. & Constr. Co., Atlanta, Ga.
Automatic Building Block Machine Co., Jackson, Mich.
Babiczky, Jos., Kansas City, Mo.
Barker & Nighswander, Toledo, Ohio.
Barr J. L. H., Batavia, Ohio.
Bedell, H. W., Bloomfield, Ontario, Can.
Behrle, H. F., Detroit, Mich.
Beirer, W. & H., Alton, Ill.
Bell, Wm., Elgin, Ill.
Bellevue Stone Co., Bellevue, Ohio.
Benner, Elwood C., Sargent, Nebr.
Berthelet Construction Co., Milwaukee, Wis.
Besser Mfg Co., Alpena, Mich.
Birnie, A. C., Ludlow, Mass.
Blaw's Collapsible Steel Centering Co., Pittsburg, Pa.
Blake, J. A., Wolcott, Ind.
Blakely, J. M., Centralia, Ill.
Blakeslee Concrete Block & Machinery Co., Columbus, O.
Bloomer Brothers Company, Newark, N. J.
Bonnot Company, The, Canton, Ohio.
Boynton, C. W., Illinois Steel Co., Chicago, Ill.
Bracker, Carl A., 571 Shaw Ave., Toronto, Ont.
Brown, Chas. C., Indianapolis, Ind.

Brown, Kirk H., Columbus, Ohio.
Brownell, F., Keokuk, Iowa.
Bueheler, John, Portage, Wis.
Burkley, Fay M., St. Paul, Minn.
Buser Concrete Construction Co., Mt. Morriss, Ill.
Canadian Petrified Brick & Stone Co., Winnipeg, Man.
Capital City Concrete Construction Co., Springfield, Ill.
Carlson, C. J., St. Joseph, Lead Co., Flat River, Mo.
Carrere, James M., 1 Madison Ave., New York City.
Castalia Portland Cement Co., Pittsburg, Pa.
Cement Brick Co., Port Huron, Mich.
Cement & Engineering News, Chicago, Ill.
Cement Machinery Co., Jackson, Mich.
Cement Machinery Manufacturing Co., Burlington, Iowa.
Cement Products Co., Burlington, Wis.
Cement Stone & Supply Co., Wichita, Kas.
Central Concrete Construction Co., Louisville, Ky.
Century Cement Machinery Co., Rochester, N. Y.
Chamberlin, C. A., Jackson, Mich.
Chard & Howe, 253 Front Street, New York City.
Chicago Portland Cement Co., Chicago, Ill.
Chickamauga Cement Co., Chattanooga, Tenn.
City Artificial Stone Co., Paris, Ill.
City Construction Co., Milwaukee, Wis.
Clark, J. W., Centralia, Ill.
Cleveland Car Co., The, West Park, Ohio.
Concrete Construction Co., Muskegon, Mich.
Concrete Construction Co., Rock Island, Ill.
Concrete Construction Co., Green Bay, Wis.
Concrete Construction Co., Steubenville, Ohio.
Concrete Stone & Sand Co., Youngstown, Ohio.
Consolidated Litholite Co., Saratoga Springs, N. Y.
Contractors' Supply & Equipment Co., Chicago, Ill.
Crowell, E. H., Crown Point, Ind.
Cummings Structural Concrete Co.,Pittsburg, Pa.
Cunningham Brothers, Brook, Ind.
Cutshall, J. M., Terre Haute, Ind.
Davis, Wm. R., Youngstown, Ohio.
DeSmet, Geo. W., 317 Chamber Commerce, Chicago, Ill.
Dever Cement Tank & Silo Co., Cassopolis, Mich.
Dexter Portland Cement Co., Nazareth, Pa.

DIAMOND CEMENT MACHINE CO., Deshler, Ohio.
DIEMAN OSWALD A., Waukesha, Wis.
DRISCOLL, JOHN, AND N. K. GOCHNAUR, Appleton, Wis.
DUNLAP, SIMON L., Indianapolis, Ind.
DUROLITHIC COMPANY, N. Tonawanda, N. Y.
DYKEMA COMPANY, THE, Grand Rapids, Mich.
EASTERN CONCRETE MACHINERY CO., Akron, Ohio.
EATON, FRED W., INDESTRUCTIBLE POST CO., Chicago, Ill.
EAU CLAIRE CONCRETE CO., Eau Claire, Wis.
EDISON PORTLAND CEMENT CO., THE, Pittsburg, Pa.
EICKEMEYER, HENRY, Bay City, Mich.
ELLEFSON, A., Ft. Smith, Ark.
ELMHURST-CHICAGO STONE CO., Elmhurst, Ill.
ENGLEBRETH, S., Beresford, S. D.
EUREKA MACHINE CO., Jackson, Mich.
EVANSTON HYDRAULIC STONE CO., Evanston, Ill.
FARRAR, C. J., Crafton, Pa.
FISHER, GEO. F., N. Tonawanda, N. Y.
FLAGG, C. W., Brazil, Ind.
FLANDERS, J. J., Glencoe, Ill.
FLINT STONE CO., THE, Toledo, Ohio.
FONCANNON & FRIST, El Paso, Tex.
FRALEY & CO., Homer, Ill.
FORTUNE, WM., Indianapolis, Ind.
FRAHM FUEL & CONSTRUCTION CO., J. B., Davenport, Iowa.
FRENCH & COMPANY, SAMUEL H., Philadelphia, Pa.
FROST & SONS, Jerseyville, Ill.
FT. WAYNE CEMENT STONE CO., Ft. Wayne, Ind.
FULTON CO. SUPPLY CO., Atlanta, Ga.
GAMMON, A. S. J., Norfolk, Va.
GENTHNER, W. J., Despatch, N. Y.
GEORGIA HYDRAULIC STONE CO., Dublin, Ga.
GILBERT, W. H., Olney, Ill.
GIVEN, JOHN P., 202 Atlantic Bldg., Norfolk, Va.
GOODWIN, HOWARD G., Akron, Wis.
GOETZMANN, A. L., Chicago, Ill.
GOODWIN, H. E., Indianapolis, Ind.
GODDARD, L. M., La Crosse, Wis.
GOODRICH, F. R., Traverse City, Mich.
GRAHAM CONCRETE CONSTRUCTION CO., Milwaukee, Wis.
GRANITE CONCRETE STONE CO., Lancaster, Pa.

Granilite Manufacturing Co., Kansas City, Mo.
Granville, John J., Saginaw, Mich.
Griswold, W. S., Elgin, Ohio.
Haas, John W., Charlotte, N. C.
Hall, James P., Jersey City, N. J.
Hamill, Geo. J., Bayside, N. Y.
Hansberger, Henry, Millersport, Ohio.
Harper, D. N., Detroit, Mich.
Harrington, J. R., Edinburg, Ill.
Harris & Sons, C. L., Sargent, Neb.
Hartwick Machinery Co., Jackson, Mich.
Haskins, H. E., Lake Geneva, Wis.
Hayes & Company, B. F., Liberty, Mo.
Hayden Automatic Block Machine Co., Columbus, Ohio.
Heasler, Veeder, Youngstown, Ohio.
Henley, H. C., St Louis, Mo.
Hoffman, S. W., Zanesville, Ohio.
Hollister Concrete Block Co., Rochester, N. Y.
Hotchkiss Concrete Stone Co., Chicago, Ill.
Hot Springs Concrete Co., Hot Springs, Ark.
Humphrey, Richard L., Philadelphia. Pa.
Hurley, Wm. Buffalo, N. Y.
Ideal Concrete Machinery Co., South Bend, Ind.
Illinois Gravel Co., Princeton, Ill.
Illinois Steel Co., Chicago, Ill.
Ironton Artificial Stone Co , Ironton, Ohio.
Jackson, F. M., Akron, N. Y.
Jaeger Automatic Machine Co., The, Columbus, Ohio.
Jaxon, Honore J., 681 W. Lake St., Chicago, Ill.
Jeffery Manufacturing Co., The, Columbus, Ohio.
Johnson, A. L., St. Louis Expanded Metal and Fireproofing Co., St. Louis, Mo.
Jones, H. N., Houston, Texas.
Kakiat Company, The, Suffern, N. Y.
Kankakee Artificial Stone Co., Kankakee, Ill.
Kelley, E. B., New York City.
Kennedy & Berry, Detroit, Mich.
Kennedy & Lowery, Detroit, Mich.
Kenney, E., Creston, Iowa.
King, Wallace, Jr., 13 Park Row, New York City.

KIRK, JOHN L., 203 Furguson Bldg., Pittsburg, Pa.
KRAMER B. K., Layfayette, Ind.
LAMB & RUTLEDGE, Newark, Ohio.
LANCASTER HOLLOW CONCRETE BLOCK CO., Lancaster, Pa.
LANDOR, EDW J., Canton, Ohio.
LANSING, H. C., Wheeling, W. Va.
LANTRY, WM. C., Milwaukee, Wis.
LARNED, E. S., 101 Milk St., Boston, Mass.
LATHERS R. H., Detroit, Mich.
LEHEW & SONS, T. M., Warsaw, Ind.
LEHIGH PORTLAND CEMENT CO., Allentown, Pa.
LILLIBRIDGE & ANDERSON, St. Charles, Ill.
LIMA ARTIFICIAL STONE CO., Lima, Ohio.
LITTLE ROCK ARTIFICIAL STONE CO., Little Rock, Ark.
LOUGH, WM., Arcola, Ill.
LOWE, GEORGE H., Arlington, Mass.
LUCAS, W. H., Newark, Ohio.
MCDONALD, IVAN C., Western Bldg, Toronto, Can.
MACK, E. C., Alton, Ill.
MANDT-POWELL CONCRETE MACHINE CO., Stoughton, Wis.
MARQUETTE CEMENT MANUFACTURING CO., Chicago, Ill.
MARTIN & CO. F. F., Beloit, Wis.
MARTIN, C. E., Piqua, Ohio.
MAYNE, F. K., Blue Springs, Neb.
MCARDLE, P. C., 3644 Grand Blvd., Chicago, Ill.
MCLAUGHLEN-MATEER COMPANY, Kankakee, Ill.
MCNARY, JOHN, Cannonsburg, Pa.
MEACHAM & WRIGHT, Chicago, Ill.
METROPOLITAN STONE CO., New York City.
MILLER, CHAS. R., Tipton, Ind.
MILWAUKEE CONCRETE & SUPPLY CO., Milwaukee, Wis.
MIRACLE PRESSED STONE CO., Minneapolis, Minn.
TWO MIRACLES CONCRETE CO., Helena, Mont.
MODERN CONSTRUCTION CO., Milwaukee, Wis.
MONSTED, A., Pabst Bldg., Milwaukee, Wis.
MOOGK, GEO. W., Waterloo, Ontario.
MUNICIPAL ENGINEERING & CONSTRUCTION CO., Chicago, Ill.
MUNNEL, SAMUEL, Cannonsburg, Pa.
NATIONAL BRIDGE CO. Indianapolis, Ind.
NATIONAL BUILDER, Chicago, Ill.

National Concrete Construction Co., Louisville, Ky.
Neck Brothers, Montello, Wis.
Newark Artificial Stone & Plaster Co., The, Newark, Ohio.
Newcastle Artificial Stone Co., Newcastle, Pa.
New Jersey Cement Stone Co., E. Organge, N. J.
Nice-Rasor Company, Barberton, Ohio.
Northwestern Expanded Metal Co., Chicago, Ill.
Northwestern Tile Co., Milwaukee, Wis.
Oil City Sand Co., Oil City, Pa.
Omega Portland Cement Co., Jonesville, Mich.
Palmer Manufacturing Co., Noyes F., Brooklyn, N. Y.
Palmer, E. D., Yankton, S. D.
Palmer Hollow Concrete Building Co., Harmon S., Washington, D. C.
Parkersburg Artificial Stone Co. Parkersburg, W. Va.
Passiac Company, Miracle Pressed Stone Co., Patterson, N. J.
Paulson, T. E., Indianapolis, Ind.
Peerless Brick Machine Co., Minneapolis, Minn.
Peerless Portland Cement Co., Union City, Mich.
Pennsylvania Cement Co., New York City.
Pettyjohn Company, Terre Haute, Ind.
Phillips Cement Stone Co., The, Columbus, Ohio.
Pierson, Arthur N., 1 Park Row, New York City.
Porter, L. E., York, Neb.
Queen City Brick Machine Co. Traverse City, Mich.
Raritan Cement Stone Manufacturing & Contracting Co., The, Perth Amboy, N. J.
Reading Brick Machinery Co., Reading, Pa.
Ricketson Mineral Paint Works, Milwaukee, Wis.
Roberts D. S., Milwaukee, Wis.
Rock Products, Louisville, Ky.
Rockford Concrete Construction Co., Rockford, Ill.
Rogers, John A., Waukesha, Wis.
Roman Stone Company, Toronto, Canada.
Rosencrans & Sons, I., Walden, N. Y.
Row, Geo. T., Circleville, Ohio.
Rowell & Son, G. D., Appleton, Wis.
Rumpf, Frank, Two Rivers, Wis.
Rubendall Brothers, Princeton, Ill.
Rupp, C. A., Buffalo, N. Y.

RUSH, J. M., Milford, Ill.
SAAL & BROOKING, Pekin, Ill.
SANDUSKY PORTLAND CEMENT CO., Sandusky, Ohio.
SCHALL, Jos., 820 Elson Ave., Chicago, Ill
SCHALLER, PHILLIP, Sac City, Iowa.
SCHATZINGER CONSOLIDATED REALTY CO., Cleveland, Ohio.
SCHLAETER COMPANY W. C., Manitowoc, Wis.
SCHOENEMAN CEMENT BLOCK CO., THE, George, Iowa.
SCHOULER, W. W., Newark, N. J.
SCHUETLE CEMENT CONSTRUCTION CO, Manitowoc, Wis.
SCHWAB & SONS COMPANY, R. J., Milwaukee, Wis.
SCOUTT, WILL J., 1016 New York Life Bldg., Chicago, Ill.
SEARS, R. B., New York City.
SENSE BROTHERS, Lafayette, Ind.
SHEA, F. J., 19 Hampden St., Springfield, Mass.
SHERER, J. P., Milwaukee, Wis.
SHEWELL F. C. Sebring, Ohio.
SHOCK & FULTON, Huntington, Ind.
SIMPSON BROTHERS CORPORATION, Boston, Mass.
SMITH COMPANY, T. L., Milwaukee, Wis.
SOUTH SIDE CEMENT CO., Milwaukee, Wis.
SOUTH SIDE ROOFING & CEMENT CO., Milwaukee, Wis.
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Wisconsin Hollow Concrete Wall Co., Milwaukee, Wis.
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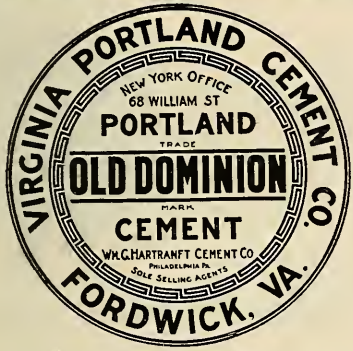

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"Giant" Portland Cement "Improved Union" Cement

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These cements have been successfully used under exacting conditions during the last 22 years in the most important constructions undertaken in this country.

Their strength, uniformity and durability have been demonstrated by the records obtained by Engineers and Inspectors of repute. Their adaptability and superiority over kindred brands have been established by the physical results obtained by leading contractors.

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Tests and Testimonials forwarded on application.

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ALWAYS UNIFORM

OUTPUT FOR 1907 OVER 13,500,000 BARRELS

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It is a book of reference and might be called the A B C of concrete work.

Copies free upon request.

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Manufacturer of

"Chicago AA" Portland Cement

We Make One Brand Only

The Best that can Be Made

53,330 bbls. used in Thebes Bridge.

6,500 " " " Kankakee Reinforced Concrete Bridge.

1,050 " " " Kenosha " " "

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"YANKTON"

PORTLAND CEMENT

MADE IN

South Dakota

A list of tests would not show to better advantage the quality of "YANKTON" Portland Cement than the statement that the United States Government accepted it for the IRRIGATION WORK at Belle Fourche, S. D., only after the most severe tests by Government experts at the mill. They failed to find cause for any criticism. **NOT ONE BARREL HAS BEEN REJECTED ON THE WORK.** Our customers receive the same cement that goes to the Government – no special run being made for the latter. **WE HAVE YET TO HEAR OF ANY BEING REJECTED BY A CUSTOMER.** EVERY BARREL MANUFACTURED WILL MEET THE SEVEREST GOVERNMENT TEST.

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Address all communications to

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YANKTON, S. D.

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Office and Laboratory Building at Cement Plant No. 3

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This building is constructed entirely of Universal Portland Cement and is one of the finest examples of artificial stone construction. The exterior is built of cast cement stone, the interior columns, beams, stairways, floors and roof being of reinforced concrete, and the partitions of hollow concrete blocks.

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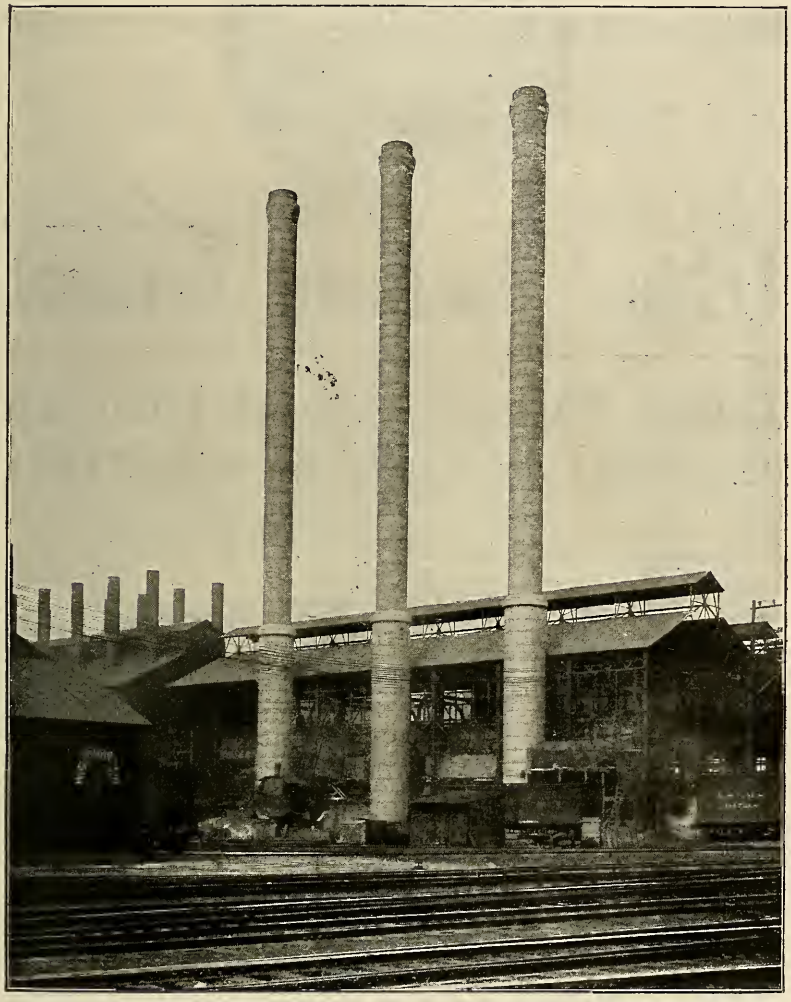
The Rookery **Chicago**

A STANDARD PORTLAND FOR UNIVERSAL USE.



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Universal Portland Cement Co.

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Manufactured By

Lehigh Portland Cement Company

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7,000,000
BARRELS YEARLY

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"FINE GRINDING IS THE SECRET OF GOOD QUALITY"

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85% THROUGH No. 200 SIEVE

CAPACITY 2,000,000 BBLS. PER ANNUM

UNEQUALED FOR HIGH-CLASS WORK

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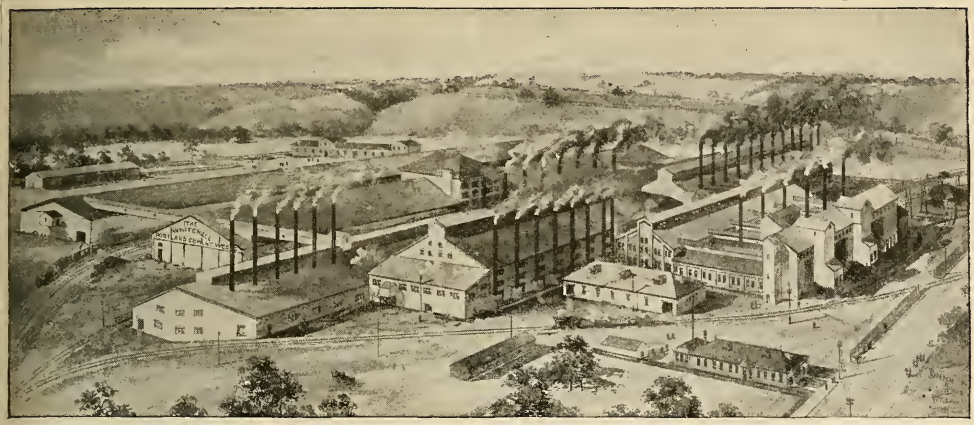

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There are some very good reasons why we place ***Whitehall*** on the pinnacle of perfect cements. Among them may be mentioned the following:

Our mill is up-to-date in every respect.

Our mill is a unit and not a number of small mills run with more or less regularity.

All of our raw material is quarried on our own property.

We have a large corps of competent chemists employed at our mill who carefully make chemical tests every hour during day and night of the raw material, as well as the finished product.

The clinker from our rotary kilns is particularly small, due to mechanical arrangements used in our mill only; consequently, on account of the smallness of the clinker, we are able to thoroughly burn the center, or, in other words, the entire clinker.

We confine ourselves to one uniform standard grade of Portland Cement, and sell it under our registered trade mark.

WHITEHALL is honestly, generously and thoroughly made with the individual features above outlined, making it the standard of perfection.

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Trade Mark—Registered

The Whitehall Portland Cement Company

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1719-24 Land Title Building

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Water-Proof Compound.

IT IS NOT A WASH

Solves the problem of making moisture-proof hollow concrete blocks.

Does away with the furring and lathing; plastering done direct on the blocks.

Many leading block manufacturers using it in their entire output.

Indispensable also for cistern and reservoir linings and all water-proof cement work.

Will absolutely prevent efflorescence.

Write for pamphlet giving comparative long-time water absorpion tests and testimonials.

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Portland Cement

Enjoys reputation for Uniform Color, Strength and High Sand Carrying Capacity.

Water-Proof Compound

Will make Concrete impervious to water.

The life of the cement building industry depends on houses being made water-proof.

WRITE US REGARDING OUR SNOW WHITE PORTLAND CEMENT

Mills: Bay Bridge, O., Syracuse, Ind., Dixon, Ill., and York, Pa.

Capacity, (1907) 5,000 bbls daily.

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Gen'l Office,

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THE HECLA COMPANY

MANUFACTURERS OF HIGH-GRADE

"HECLA"

ROCK PORTLAND CEMENT

Shipping facilities unexcelled, plant being located on four railroads and deep water; large storage capacity, thus insuring prompt delivery.

All cement guaranteed to pass Standard test adopted by the American Society for Testing Materials.

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STRENGTH

EXCELLENT COLOR.

Specially adapted for sidewalks and the manufacturer of high grade Artificial Stone, having been used in many large buildings, notably:—

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60,000 BBLS. USED IN CONSTRUCTION OF THE
NEW WOOD MILL AT LAWRENCE, MASS.
THE LARGEST WOOLEN MILL IN THE WORLD.

Used by the U. S. Government in important work, and by the various departments of NEW YORK CITY.

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ALWAYS THE SAME
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MANUFACTURED BY THE

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Is the highest grade pure Portland Cement, containing no slag and no marl. Every barrel is guaranteed to pass the specifications of the American Society of Civil Engineers, and the United States Government specifications. Is most finely ground, light in color, and high in tensile strength, and especially recommended for block construction and sidewalks.

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St. Louis, Mo.

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WHAT THE ENGINEER WANTS.

THE RECOGNIZED WESTERN STANDARD.

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138 ARTIFICIAL PORTLAND CEMENT STONE PLANTS NOW USING THIS BRAND EXCLUSIVELY.

AMERICA'S OLDEST CEMENT

Thirty-Two Years On The Market

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The Most Uniform Cement Made In This Or Any Other Country

Very Low In Sulphuric Anhydride

COPLAY CEMENT MFG. CO.

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DEXTER PORTLAND CEMENT

The Highest Standard Attainable

UNEQUALLED FOR

REINFORCED CONCRETE
CEMENT SIDEWALKS
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ESTABLISHED 1844 PHILADELPHIA

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Manufacturers of High Grade

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CAPACITY 5,500 BARRELS DAILY

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Manufactures 1500 Barrels per day

Of the very best grade of Portland Cement by the old wet method, using Petoskey limestone, and clay, having abandoned the use of marl entirely. Every barrel is guaranteed to be as good as any on the market.

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That's what Cement Block Makers should be prepared to give if they are to be Successful—The Architect demands Variety in design as well as Size.

THE HERCULES MACHINE

MAKES ALL SIZES and designs of Blocks and in addition WATERTABLES, SILLS, ETC., up to about 6 feet long. There is no other like it.

EVERY MACHINE IS A COMPLETE STONEYARD IN ITSELF.

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Quality will be remembered
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Guaranteed to be an absolutely pure Portland Cement made from Travertine and Clay by the Wet Process, giving greatest uniformity of color and fineness and highest tensile or crushing strength.

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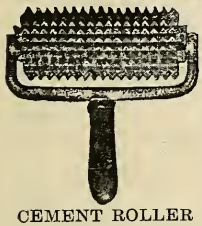

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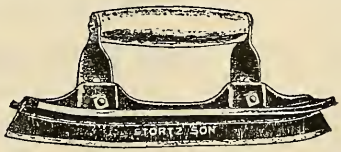
NONE BETTER **FRICTION METAL**

Cement and Concrete Workers, Contractors' Asphalt and Pavers' Tools.

Tampers, Jointers, Groovers, Edgers, Concrete Knives, Shovels, Picks, Etc.



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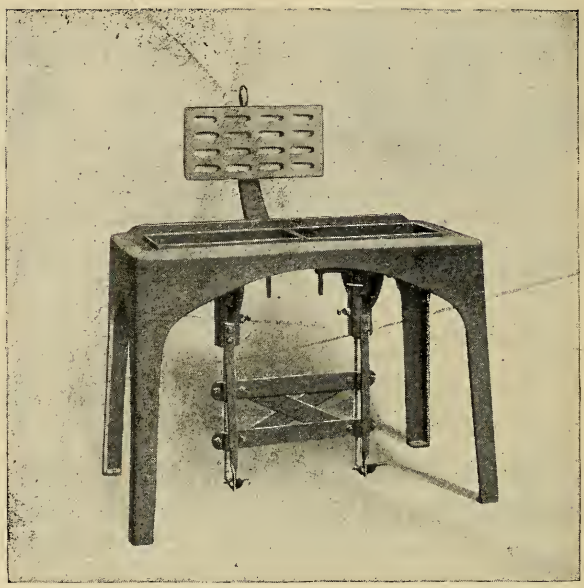
The Wickes Cement Shingle Machine

for the production of reinforced Portland cement shingles, hips, ridges, and tile butts. Only the one machine required for producing all material necessary for a plain or fancy roof. No special construction of roof required. Send for catalogue.



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Can Be Used With Absolute SAFETY.

Hundreds of Users Have Testified to the Excellent Results Obtained. Manufactured and Guaranteed by

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Corrugated Bars

FOR REINFORCED CONCRETE.

MOST EFFICIENT BOND

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EASIEST HANDLED

The three determining factors in the selection of concrete reinforcement.

Expanded Metal & Corrugated Bar Co.,

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Reinforced concrete grows stronger with age—is economical in first cost and saves an immense amount of time in construction. The Farwell, Ozmun, Kirk & Co. building at St. Paul, Minn., the largest warehouse in the West, with nine stories and nearly half a million square feet of floor space, was completed in six months.

We are prepared to furnish you with preliminary designs and carefully prepared estimates of your building entirely free of charge. ***We solicit contracts on a cost-plus-a-fixed-sum-basis.*** We are always ready to send to any portion of the country a most complete construction organization and elaborate equipment for the erection of any structure, no matter how large.

The Kahn System is backed by a million dollar organization, a staff of more than seventy-five experienced college graduated engineers, and equipment to handle every detail of a building, no matter how large, with a maximum economy, maximum engineering skill and maximum speed.

Send your name for free subscription to the "Trussed Concrete Bulletin," stating the particular class of buildings you are interested in.

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EXPANDED METAL.

The best fabric ever invented for the reinforcement of Concrete.

It is made in varying sizes and weights to meet all requirements in:

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Sales in 1906 over 25,000,000 square feet.

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The Only Machine Absolutely Free from Infringement

Showing Machine Open with Two Blocks Made at Once Ready for Removal

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A COMBINATION THAT IS REVOLUTIONARY

MULTIPLE—Makes any size or number of blocks in its capacity.

AUTOMATIC—One operation opens the machine and removes all cores, dividing plates, etc. A reverse movement again closes the machine and locks it completely.

H. S. Palmer Hollow Concrete Block Co.

1450 Girard Street, N. W. WASHINGTON, D. C.

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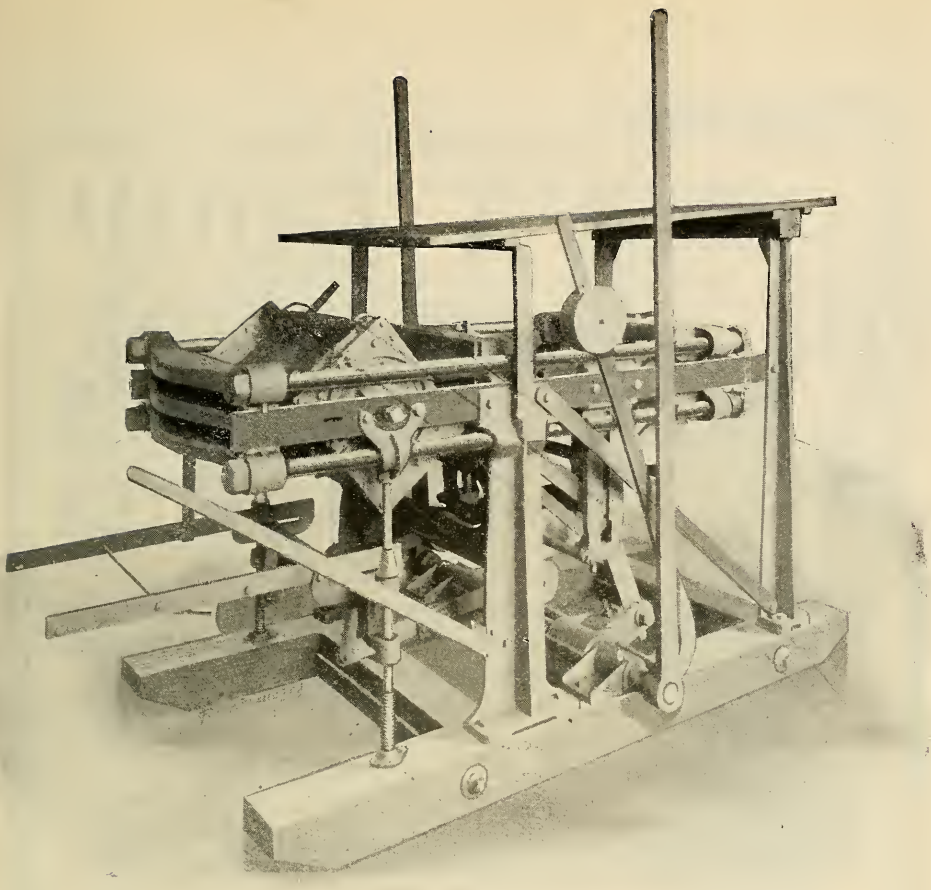
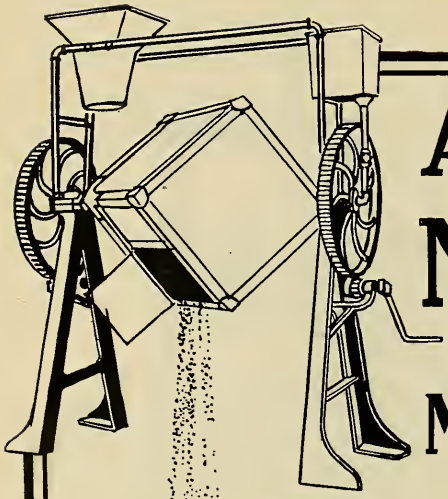


The Latest and Best Concrete Block Machinery. Our 1906 catalogue, just issued, describes it fully, and also tells all about the two-piece wall made from a wet mixture of true concrete, bonded with the indestructible header bond and containing a continuous horizontal air space.

This large catalogue, fully illustrated, free for the asking.

The American Hydraulic Stone Co.,

Century Building, Denver, Colorado.



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THE principle of the cube has been tested and demonstrated as by far the best principle for thoroughly mixing concrete.

Three revolutions of the cube renders a perfect mix, the materials having broken and assembled eighteen different times.

The Miracle Mixer for hand or power stationary or on skids is the most practical and all around satisfactory mixer made. Cuts your labor in two and costs but little.

The mixing determines the quality of your concrete work to a large extent. The better your mix the better your concrete, or if your mixing is better you will require less cement. Money saved is money earned. The Miracle Mixer will save fifty per cent. of your labor mixing by hand.

Price, $110

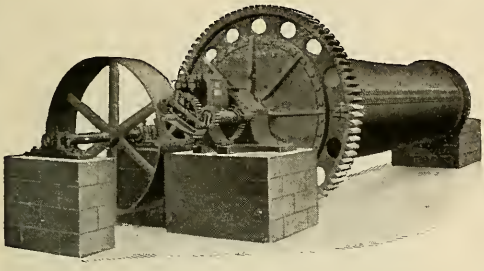
Send for complete information and prices.
Ask for Catalog No. 13.

Miracle CONCRETE

Miracle Pressed Stone Co.
Minneapolis.

Allis-Chalmers Company

MILWAUKEE, WISCONSIN, U. S. A.



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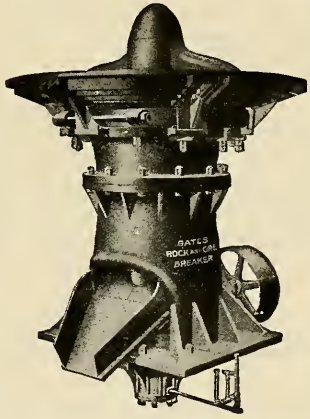
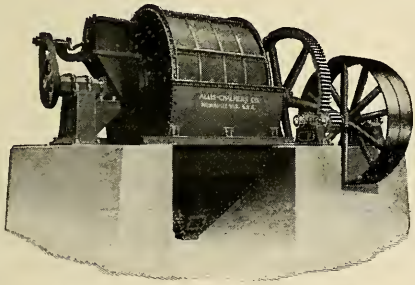
Cement-Making Machinery

for every stage in Cement making by either the Wet or Dry Process.

Rock Breakers
Crushers
Dryers
Elevators



Style "K," Gates Rock and Ore Breaker.



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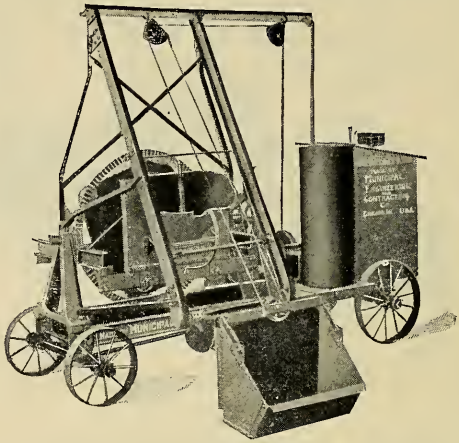
We are prepared to make most attractive quotations on Silex Linings, C. I. F., New York, delivery subject to ocean transit; and we solicit inquiries from users of this material.

The First Consideration

When Buying a Concrete Mixer.



The first requirement when buying a concrete mixer is that it will produce a **perfect product.** Failing in this any other features of claimed excellence are **unworthy of consideration.**

It is manifest that any form of paddles, scoops, shelves or blades in a mixing receptacle will become **coated with cement** and form **pockets** which will **scoop up** as much as they will hold of some **ingredient** as it enters and this material is carried around by these devices, cutting through but not mixing with the main mass at the bottom of the mixing chamber and simply **slides out** when the batch is discharged producing a **streaky concrete.**

It is also evident that in any kind of a mixer having inside blades or shelves as mixing appliances that **only** that portion of the material which is in **motion** is being mixed at **any one time** and the portion in **repose** carried by these devices cannot receive the **same** amount of mixing as that which is **changing its relative position.**

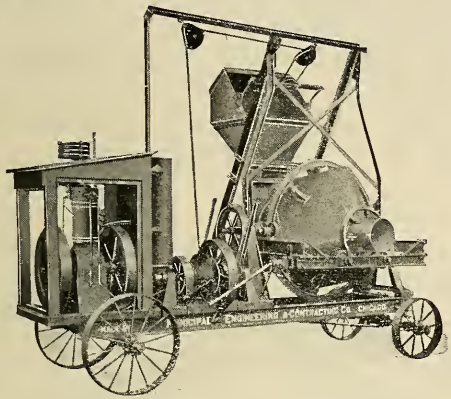
In trough mixers, provided with spirals, the materials are simply fed along in **layers** as they are put in depending upon the **uncertain** and **unreliable** action of **water** for the distribution of the cement.

A Perfect Mixer

The Chicago Improved Cube Mixer holds the entire batch together when mixing, gives it the many **lateral** and **longitudinal** movements obtained from the sides of the revolving cube, there are no **obstructions** to **pocket** the materials, **all** the batch is mixing all the time and **more thoroughly mixed** than by **any other** method and the product must be **perfect.**

At **15** revolutions per minute the entire contents of the cube are thrown from side to side and the coarser aggregates are **forced** into the **voids 90** times a more **rapid** and more **thorough** mixing than can be produced by **any other** type of mixer.

What Experimental Test Will Prove.



Take a Chicago Improved Cube Mixer and make an **experimental test.** Make a **small batch** consisting of 2 cubic feet of sand, one-half sack of cement and about 325 cubic inches of water, revolve it 16 times in the cube, add 4 pounds of red oxide of iron, give it 16 more revolutions, discharge and make into blocks. Steam the blocks 12 hours and it will be found that **every part** of the **surface** will be **evenly** colored, break the block and the **same** conditions will be found to **prevail** throughout.

Now take the same size batch and treat in **precisely** the **same** manner but mix in any style of a batch mixer having any form of **blades** or **scoops** as mixing devices or a continuous mixer having any form of **spirals** as mixing appliances and it will be found upon examination of the blocks that they are **laminated** or **spotted** in color both on the **surface** and **throughout** the block, proving beyond question that **none** but the **cube** produces a **perfect** mixture.

The Most Rapid of All Mixers.

The superiority of the Chicago Improved Cube Mixer is not only in the **unequalled** quality of **product** but also in the **perfection** of **mechanical equipment.**

It is provided with a **steel charging elevator,** carried entirely by the same truck which supports the mixer, and engine, and having a **charging bucket** which loads within **14 inches** of the ground, requiring less **manual labor** than any other mixer.

It is discharged by means of an **automatic discharging device,** operated entirely by the **same** engine which propels the mixer.

Equipped with these automatic labor saving devices, the Chicago Improved Cube Concrete Mixer will produce a batch of **absolutely perfect concrete a minute** and maintain this record **indefinitely,** a record which has **never been equalled** by any other mixer.

Sizes and mountings for every requirement. Write for catalogue No. 59.

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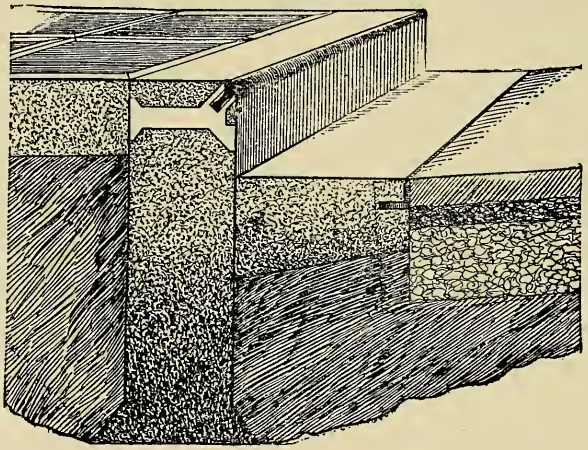

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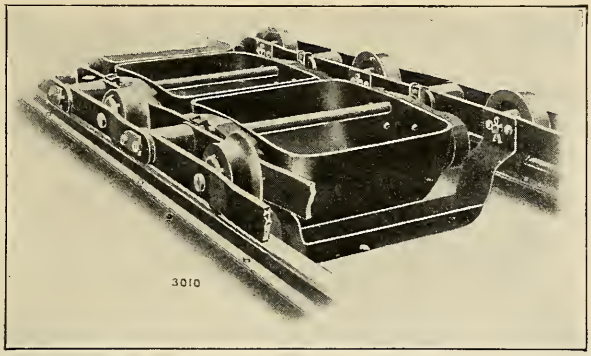

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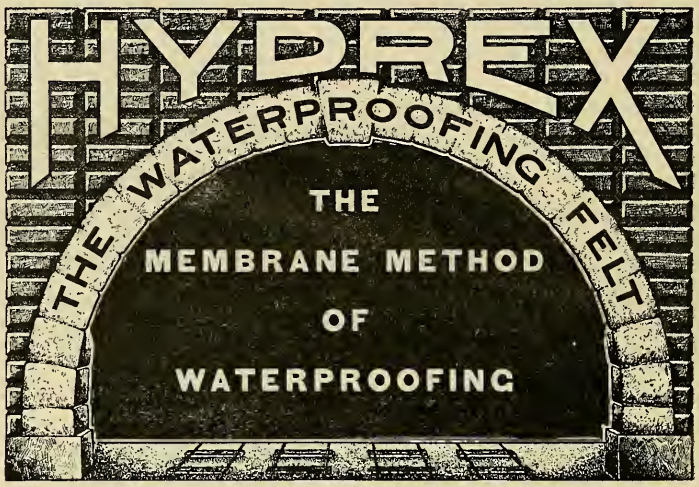

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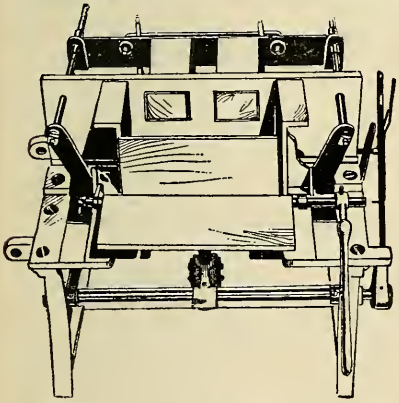

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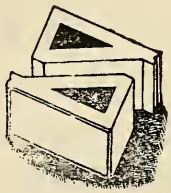

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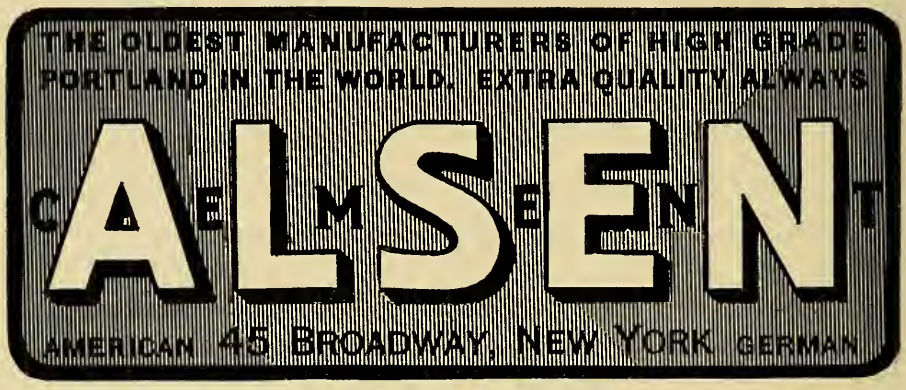

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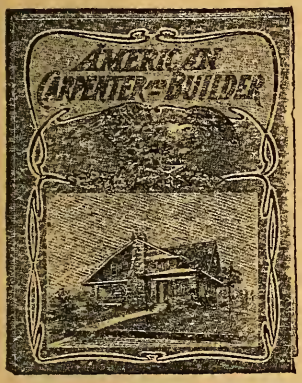

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